SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MARCH 1918.

CONTENTS.

GENERAL PHYSICS.

PAGE
211. The Hygrostat and its Management. *R. Kempf* 89
212. Dividing Engine for Ruling Gratings. *H. J. Grayson* 89
213. Instrument for Rapid Density Measurements on Board Ship. *A. L. Thuras* 89
214. Vacuum Balance Cases. *B. Blount & W. H. Woodcock* 90
215. Condensation Pump. *W. C. Baker* 90
216. Use of Stereoscope for Viewing Contour Maps. *H. Hubert* 90
217. Innovations with Respect to Mircomanometers. *M. Berlowitz* 90
218. Measuring the Elastics of Small Bodies. *C. Barus* 91
219. Brinell Ball-hardness Test. *Guillery* 91
220. Demonstration of Formulæ for Beams and Plates. *Mesnager* 91
221. Use of Soap-films in Solving Torsion Problems. *A. A. Griffith & G. I. Taylor* 91
222. Recurrent Tetrahedral Deformations. *B. K. Emerson* 93
223. The Discharge of Gases under High Pressures. *L. Hartshorn* 96
224. Influence of Air-resistance on Translation of Moving Bodies. *Z. Carrière* 96
225. Kinematics of a Physical Wave. *K. Uller* 97
226. Characteristic Frequency and Atomic Number. *H. S. Allen* 97
227. Atomic Frequency and Atomic Number-frequency Formulæ. *H. S. Allen* 97
228. Electronic Frequency and Atomic Number. *H. S. Allen* 98
229. Crystal Structure. *A. C. Crehore* 98
230. The Brownian Movement of Single Particles. *R. Fürth* 99
231. The Velocity of Gravitational Propagation. *M. v. Laue* 100
232–233. 100
234. Diurnal Variation of Wind with Height. *L. Dunoyer & G. Reboul* 100
235. Relation between Pressure and Water-level in a Well. *E. G. Bilham* 100
236. Meteorological Observations during Sub-Antarctic Cruise. *J. P. Ault* 101
237. Turbulence in Lower Atmosphere. *G. I. Taylor* 101
238. Distribution of dissolved Oxygen in Tidal Areas. *J. W. Sale & W. W. Skinner* 102
239. Nitrogen, Chlorine, Sulphates in Rain and Snow. *E. L. Peck* 102
240. Eruption of the Volcano Quetzaltepeque. *A. Lacroix* 102

PAGE
241. The Coral-reef Problem. *E. W. Skeats* 103
242. Geographical Conditions for Solar Eclipse, 1919. *A. R. Hinks* 103
243. Absorption of Water on Moon and Planets. *A. Véronnet* 103
244. Spectrum of Wolf's Comet. *V. M. Slipher* 103
245. Atmospheric Refraction. *W. T. Neill* 104
246. Parallax of Faint Proper-motion Star near α Centauri. *R. Innes* 104
247. Relativity and the Displacement of Fraunhofer Lines. *C. E. St. John* ... 104
248. Light-curve of V Bootis. *G. B. Lacchini* 104
249. Observations of Mira Ceti. *G. B. Lacchini* 104
250. Parallax of P Ophiuchi. *J. C. Solá* 104
251. Equations of Radiative Transfer of Energy. *J. H. Jeans* 105
252. Evolution and Radiation of Gaseous Stars. *J. H. Jeans* 105
253. Conditions in Interior of a Star. *A. S. Eddington* 105
254. Radial Velocities of Star Clusters. *V. M. Slipher* 105
255. Parallax of Ring Nebula in Lyra. *A. van Maanen* 105
256. Cusped Orbit of Dr. Hill. *R. Moritz* 105

LIGHT.

257. Triple Cemented Telescope Objectives. *T. Smith & [Miss] A. B. Dale* ... 106
258. On a Class of Multiple Thin Objectives. *T. Smith* 106
259. Humidity Correction for Pentane Lamp. *K. Takatsu & M. Tanaka* 106
260. Kirchhoff's Theory of Diffraction. *A. Rubinowicz* 107
261. Limit of Interference in Interferometer. *M. N. Saha* 107
262. Interferometry of Small Angles. *C. Barus* 107
263. Correction Terms for Concave Grating. *H. Nagaoka* 107
264. 108
265. Spectrum of Neon. *K. W. Meissner* 108
266. Absorption of Hard X-rays in Gases. *M. Lang* 108
267. K-Series of the Röntgen-ray Spectrum of Gallium. *H. S. Uhler & C. D. Cooksey* 109
268. Spectrography of Röntgen Rays. *de Broglie* 110
269. X-ray Spectra. *J. Brentano* 110
270. X-ray Absorption Phenomena. *M. de Broglie* 110
271. Spectra of Isotropes. *W. D. Harkins & L. Aronberg* 111
272. Critical Absorption of some Elements for X-rays. *F. C. Blake & W. Duane* 111
273. Radium Content of Sea-salt. *C. W. Hewlett* 112
274. Penetrating Radiation on the Obir. *V. F. Hess & M. Kofler* 113
275. Radio-activity of Archæan Rocks. *W. F. Smeeth & H. E. Watson* 113

HEAT.

276. Thermal Expansion of Tungsten. *A. G. Worthing* 114
277. Specific Heat of Liquid Ammonia. *N. S. Osborne & M. S. Van Dusen* ... 114
278. Latent Heat of Vaporisation of Ammonia. *N. S. Osborne & M. S. Van Dusen* 114
279. Solubility of Sodium Sulphate as Means of determining Temperatures. *T. W. Richards & V. Yngve* 115
280. Temperature Determinations by Eutectic Alloys. *C. P. Steinmetz* 116
281. Heat Convection in Air. *W. P. White* 116
282. Vapour Pressure of Liquid Ammonia. *F. G. Keyes & R. B. Brownlee* 117
283. Limits of Inflammability of Methane-Air Mixtures. *W. Mason & R. V. Wheeler* 117
284. Adiabatic Invariants of Mechanical Systems. *J. M. Burgers* 118

V.
19

PAGE
285. Determination of the Critical Point of Hydrogen. *H. K. Onnes, C. A. Crommelin, & P. G. Cath* ... 119
286. Spectrum of a Rotating Molecule. *J. M. Burgers* ... 120
287. ... 120
288. The Constant σ in the Stefan-Boltzmann Law. *M[arya] Kahanowicz* ... 120
289. A Physical Interpretation of Entropy. *J. Lahousse* ... 121

ELECTRICITY AND MAGNETISM.

290. Unipolar Induction and Electron Theory. *G. B. Pegram* ... 122
291. "X-ray" Determination of "*h*." *F. C. Blake & W. Duane* ... 122
292. The Radius of the Electron. *J. W. Nicholson* ... 123
293. Problems of the Potential Theory. *A. Bolliger* ... 123
294. Ions produced by Spraying of Water. *J. J. Nolan* ... 124
295. Total Ionisation by Slow Electrons. *J. B. Johnson* ... 124
296. Time Variation of Potassium Photoelectric Cell. *H. E. Ives* ... 125
297. Measurement of Ionisation in Geissler Tubes. *E. Rumpf* ... 125
298. Magnetic Phenomena at Anode. *G. Gouy* ... 125
299. Specific Resistance and Thermoelectric Power of Calcium. *C. L. Swisher* 126
300. Electrical and Thermal Properties of Iron Oxide. *C. C. Bidwell* ... 126
301. Thermoelectric Properties of Fused Metals. *C. R. Darling & A. W. Grace* 127
302. Large Laboratory Electromagnet. *P. Weiss* ... 127
303. Magnetisation as a Function of Temperature. *A. Piccard* ... 128
304. The Magneton and Solution of Paramagnetic Salts. *P. Weiss* ... 128
305. Energy of Magnetisation of a Crystal of Iron. *K. Beck* ... 128
306. Magnetic Storm and Aurora, Dec. 16-17, 1917. *C. Chree* ... 128
307. Dosimetry in X-Radio-Therapy. *Guilleminot* ... 129
308. New Apparatus for measuring Doses of Röntgen Rays. *H. Guilleminot* ... 129

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

309. Density of Helium by Means of a Quartz Microbalance. *T. S. Taylor* ... 130
310. Some Substitutes for Platinum Ware. *R. F. Heath* ... 130
311. Molecular Attraction. XV. *J. E. Mills* ... 130
312. Liquid Crystals. II. *W. J. H. Moll & L. S. Ornstein* ... 131
313. Transition Temperatures as Fixed Points in Thermometry. *T. W. Richards & V. Yngve* ... 132
314. Thermal Treatment of Steel. *M. E. Leeds* ... 132
315. The Heterogeneity of Steels. *G. Charpy & S. Bonnerot* ... 133
316. Thermal Dilatation of Carbon Steels. *J. Driesden* ... 133
317. The Heterogeneity of Steels. *H. le Chatelier & E. L. Dupuy* ... 134
318. Osmotic Pressure. *O. J. Lodge, A. W. Porter, F. Tinker, W. R. Bousfield* 134
319. Precipitation of Colloidal Au on Metallic Surfaces. *E. B. Spear & K. D. Kahn* ... 134
320. Mechanism of the Ionisation Process. *J. Kendall & J. E. Booge* ... 134
321. Hydrogen and Calomel Electrode. *G. N. Lewis, T. B. Brighton, & R. L. Sebastian* ... 135
322. Electrolysis of Solutions of the Rare Earths. *L. M. Dennis & A. B. Ray* 136
323. Lead Standard Cell. *W. E. Henderson & G. Stegeman* ... 136
324. Theory of the Lead Accumulator. *C. Féry* ... 136

NAME INDEX.

Allen, H. S., 226, 227, 228.
Aronberg, L., 271.
Aubert, M., 264.
Ault, J. P., 236.
Baker, W. C., 215.
Barus, C., 218, 262.
Beck, K., 305.
Berlowitz, M., 217.
Bidwell, C. C., 300.
Bilham, E. G., 235.
Blake, F. C., 272, 291.
Bolliger, A., 293.
Blount, B., 214.
Bonnerot, S., 315.
Booge, J. E., 320.
Bousfield, W. R., 318.
Brentano, J., 269.
Brighton, T. B., 321.
de Broglie, 268.
de Broglie, M., 270.
Brownlee, R. B., 282.
Burgers, J. M., 284, 286.
Carrière, Z., 224.
Cath, P. G., 285.
Charpy, G., 315.
le Chatelier, H., 317.
Chree, C., 306.
Cooksey, C. D., 267.
Crehore, A. C., 229.
Crommelin, C. A., 285.
Dale, [Miss] A. B., 257.
Darling, C. R., 301.
Dennis, L. M., 322.
Driesden, J., 316.
Duane, W., 272, 291.
Dunoyer, L. 234.
Dupuy., E. L., 317.
Dusen, M. S. Van, 277, 278.
Eddington, A. S., 253.
Emerson, B. K., 222.
Federhofer, K., 287.
Féry, C., 324.
Fürth, R., 230.
Gouy, G., 298.
Grace, A. W., 301.
Grayson, H. J., 212.
Griffith, A. A., 221.
Guilleminot, 307.
Guilleminot, H., 308.
Guillery, 219.
Harkins, W. D., 271.
Hartshorn, L., 223.
Heath, R. F., 310.
Henderson, W. E., 323.
Hess, V. F., 274.
Hewlett, C. W., 273.
Hinks, A. R., 242.
Hubert, H., 216.
Innes, R., 246.
Ives, H. E., 296.
Jeans, J. H., 251, 252.
John, C. E. St., 247.
Johnson, J. B., 295.
Kahanowicz, M[arya], 288.
Kahn, K. D., 319.
Kempf, R., 211.
Kendall, J., 320.
Keyes, F. G., 282.
Kofler, M., 274.
Lacchini, G. B., 248, 249.
Lacroix, A., 240.
Lahousse, J., 289.
Lang, M., 266.
v. Laue, M., 231.
Leeds, M. E., 314.
Lewis, G. N., 321.
Lodge, O. J., 318.
van Maanen, A., 255.
Mason, W., 283.
Mees, C. E. K., 233.
Meissner, K. W., 265.
Mesnager, 220.
Mie, G., 232.
Mills, J. E., 311.
Moll, W. J. H., 312.
Moritz, R., 256.
Nagaoka, H., 263.
Neill, W. T., 245.
Nicholson, J. W., 292.
Nolan, J. J., 294.
Onnes, H. K., 285.
Ornstein, L. S., 312.
Osborne, N. S., 277, 278.
Peck, E. L., 239.
Pegram, G. B., 290.
Piccard, A., 303.
Porter, A. W., 318.
Ray, A. B., 322.
Reboul, G., 234.
Richards, T. W., 279, 313.
Rubinowicz, A., 260.
Rumpf, E., 297.
Saha, M. N., 261.
St. John, C. E., 247.
Sale, J. W., 238.
Sebastian, R. L., 321.
Skeats, E. W., 241.
Skinner, W. W., 238.
Slipher, V. M., 244, 254.
Smeeth, W. F., 275.
Smith, T., 257, 258.
Solá, J. C., 250.
Spear, E. B., 319.
Stegeman, G., 323.
Steinmetz, C. P., 280.
Swisher, C. L., 299.
Takatsu, K., 259.
Tanaka, M., 259.
Taylor, G. I., 221, 237.
Taylor, T. S., 309.
Thuras, A. L., 213.
Tinker, F., 318.
Uhler, H. S., 267.
Uller, K., 225.
Van Dusen, M. S., 277, 278.
Véronnet, A., 243.
Watson, H. E., 275.
Weiss, P., 302, 304.
Wheeler, R. V., 283.
White, W. P., 281.
Woodcock, W. H., 214.
Worthing, A. G., 276.
Yngve, V., 279, 313.

SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MARCH 1918.

GENERAL PHYSICS.

211. *The Hygrostat and its Management.* **R. Kempf.** (Zeits. Instrumentenk. 37. pp. 193–198, Oct., 1917).—Describes an apparatus for maintaining at a constant relative humidity the air within a closed space by covering the floor of the space with an aqueous solution of sulphuric acid of a strength determined by the relative humidity required. Certain precautions to be attended to are set out, of which the following are the most important:—(1) Moderate and uniform changes of temperature of the apparatus as a whole, including the acid, produce an insignificant effect upon the relative humidity. (2) Local changes of temperature affecting part of the apparatus only, produce sudden and considerable changes of relative humidity of the enclosed area, and are therefore to be carefully guarded against. (3) Gentle agitation of the enclosed air and of the acid is necessary to secure accurate results. [See Abs. 1678 (1908).] R. C.

212. *New Dividing Engine for Ruling Diffraction Gratings.* **H. J. Grayson.** (Roy. Soc. Victoria, Proc. 30. Pt. 1. pp. 44–95, 1917.)—A full and detailed description, illustrated with numerous drawings and photographs, of the author's new engine for ruling gratings of between 20,000 and 7000 lines per inch. The different sections of the paper deal with (i) the driving mechanism, a small hot-air engine of about 1/40 h.p., and the transmission of the drive to the ruling engine; (ii) the housing of the ruling engine to avoid vibration and temperature-change during the course of a ruling; (iii) the screw, including a description of the grinding nut and of the abrasives used together with the manner of their preparation and grading, an account of the preliminary hand grinding and of the later grindings with semi-automatic control, and, finally, the method of testing the screw and its bearings during final correction and adjustment; (iv) the ratchet head; (v) the thrust plate, finally constructed of sapphire; and (vi) the diamond, its preparation and mounting.

J. W. T. W.

213. *An Instrument for Accurate and Rapid Density Measurements on Board Ship.* **A. L. Thuras.** (Washington Acad. Sci., J. 7. pp. 605–612, Dec. 19, 1917.)—The ordinary hydrometer has long been discarded for accurate oceanographic work because of the irregularities and variations in its indications. Almost all of these errors are to be found at the surface of the liquid measured, namely, changes in the surface tension, impurities on the surface influencing the shape of the meniscus on the stem of the hydrometer, and irregularities in the wetting of the stem. These errors are all eliminated in the float, or bobbin, of total immersion. This method has therefore been studied with the object of making rapid and accurate density measurements on board ship. Previous work on the subject by Reggianni, Nansen, Richards, Lamb, and Lee is first described. Following this comes a detailed account of the simple apparatus recommended by the author, who finds that with carefully calibrated bobbins a density measurement of a liquid of known temperature coefficient can be made in less than 10 mins. to an accuracy of more than two in the fifth decimal place. The particular advantage of the method lies in the facts that (1) by changing the temperature of the liquid its density can easily and quickly be brought exactly to the density of the bobbin, and (2) at equilibrium temperature the sensitivity of the method is unaffected by the motion of the vessel, the liquid and bobbin having the same density. H. H. Ho.

214. *Vacuum Balance Cases.* **B. Blount** and **W. H. Woodcock.** (Chem. Soc., J., Trans. 113. pp. 81–84, Jan., 1918.)—Two vacuum balance cases are described by the authors. The one is made of gunmetal and reproduces the ordinary or wooden balance case in every essential, but in spite of all precautions there was a leakage of somewhat less than 0·01 mm. of pressure per hour. It was necessary to obtain and keep a vacuum of something like 0·001 mm. for an hour without the continued or renewed use of a pump, and this was attained by mounting a Bunge balance with a 15-cm. beam in a glass bell-jar, which was ground to fit a thick glass plate carried on a gunmetal plate [compare Abs. 4 (1918)]. Photographs of the balances are given. T. S. P.

215. *Condensation Pump.* **W. C. Baker.** (Phys. Rev. 10. pp. 642–644, Dec., 1917.)—Describes in detail, with diagrams, the construction of a very simple form of condensation pump which requires very little skill in glass-blowing. A. W.

216. *Use of Stereoscope for Viewing Contour Maps.* **H. Hubert.** (Comptes Rendus, 165. pp. 1059–1060, Dec. 24, 1917.)—Proposes the use of a stereoscope for giving a clear idea of the contours of two or more superposed surfaces such, for example, as the ground surface and one or more geological strata. It is suggested that the maps be drawn by hand to a much-enlarged scale and then reduced photographically. J. W. T. W.

217. *Innovations with Respect to Micromanometers.* **M. Berlowitz.** (Zeits. Vereines Deutsch. Ing. 61. pp. 969–978, Dec. 8, 1917.)—Interest in air measurements has been aroused during recent years to an unusual degree, particularly as regards ventilators and compressors; in consequence, a large number of manometric improvements have been forthcoming. The author here presents a summary of the various innovations which have been proposed. The differential manometer of G. Reeknagel, which itself was a development of Peclet's earlier apparatus, and which for a number of years was the only instrument for measuring pressures below $\frac{1}{10}$ water barometer, is first described in detail. Owing to serious inconveniences involved in the use of this instrument, a new construction was proposed by Krell to which he gave the name micromanometer. A full description of this apparatus is given in the paper. Further improvements by Berlowitz and Schultz are then discussed, the various details being illustrated by eight diagrams. The paper concludes with a mathematical discussion of the mechanism of manometric measurement accompanied by two tables of results. H. H. Ho.

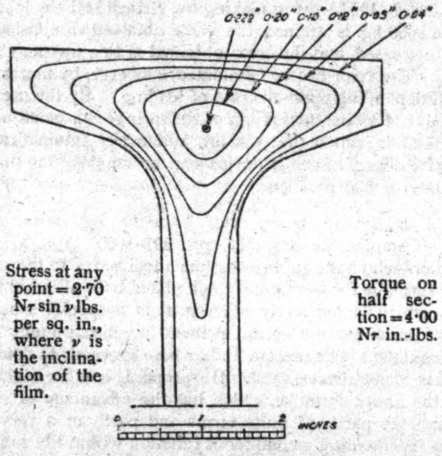
218. *Measuring the Elastics of Small Bodies.* **C. Barus.** (Nat. Acad. Sci., Proc. 3. pp. 693–696, Dec., 1917.)—Describes an interferometer method of measuring the elastic modulus of a small body such as a crystal. The example chosen for a description of the method is a small rod of ebonite, 2·4 cm. long, 0·135 cm. diam., and kept under a minimum load of 1 kg. With pressures varying in the sequence, (1, 2, 3, 2, 1), (1, 2, 3, 4, 3, 2, 1), etc., kg. the contractions appeared to indicate well-developed hysteresis loops, with the superimposed continuous viscous deformation which results from loading. J. W. T. W.

219. *Brinell Ball-hardness Test.* **Guillery.** (Comptes Rendus, 165. pp. 468–471, Oct. 8, 1917.)—If in making the Brinell test the load is removed as soon as the 3000 kg. is attained, the value obtained diminishes as the rate of loading is increased, and the error obtained in this way may amount to as much as 8 %. The error can be eliminated, however, by increasing the load by an amount depending upon the rate of loading. By the use of a spring-loaded ball valve in which the tension of the springs can be adjusted, a device has been realised in which the pressure attained is automatically regulated by the rate of loading. Such a device can be employed in making Brinell tests at the rate of 600 per hour. F. C. A. H. L.

220. *Rigid Demonstration of the Formulæ for Beams and Plates.* **Mesnager.** (Comptes Rendus, 165. pp. 997–1000, Dec. 17, 1917.)—The different authors who have applied mathematical series to the calculation of the elasticity formulæ for beams and thick plates, have all admitted implicitly that a series which is uniformly convergent in a special zone and merely convergent at the contour does not present any discontinuity between this zone and its contour. The present author here proceeds to demonstrate that this assumption is not always valid. He proposes a more rigid method for establishing the above formulæ, which has the advantage of employing an expression made up partly of finite terms and partly of a very rapidly convergent series representing a continuous function within the zone and at the contour. The method is then applied to the simple case of elasticity in two dimensions, namely, the problem of the symmetrical beam as referred to the origin of coordinates and to the longitudinal axis. H. H. Ho.

221. *Use of Soap-films in Solving Torsion Problems.* **A. A. Griffith** and **G. I. Taylor.** (Inst. Mech. Eng., J. No. 1. pp. 755–789; Disc., 789–794, Jan., 1918. Engineering, 104. pp. 652–655; Disc., 650–652, Dec. 21, and pp. 699–701, Dec. 28, 1917.)—The equations which represent the torsion of an elastic bar of any uniform cross-section are of exactly the same form as those which represent the displacement of a soap-film, due to a slight pressure acting on its surface, the film being stretched over a hole in a flat plate, of the same shape as the cross-section of the bar. The theory of this relationship is outlined in a mathematical appendix to the paper, and it is shown that advantage may be taken of the analogy to find the stresses and torsional stiffness of a twisted bar or shaft of any cross-section whatever by making

appropriate measurements of soap-films. Thus there is no restriction on the shape of the sections with which the method is capable of dealing, whereas the number of cases in which the equations can be solved mathematically is extremely limited. The method employed is as follows: A hole is cut, in a thin plate, of the section required to be investigated, and a circular hole of a predetermined diam. is cut alongside it. The plate is placed in a box, and soap-films are stretched across the holes. The films are blown out slightly by reducing the air pressure on one side of them. By making suitable measurements of the shape of the resulting film surfaces, it is possible to find the stresses in a bar of the given section, in terms of the stresses in a circular bar of the same diam. as the circular hole, when the two bars are twisted through the same angle per unit length. It is equally easy by means of other measurements to find the ratio of the torques which must be applied to the two bars in order to produce the same twist in each. The measurements required are (i) the inclination of the film to the plane of the plate at at any point, for the determination of the stresses, (ii) the determination of the contour lines of the film, (iii) the comparison of the displaced volumes of the test film and the circular standard for finding the corresponding torque ratio.



Stress at any point = 2·70 $N\tau \sin \nu$ lbs. per sq. in., where ν is the inclination of the film.

Torque on half section = 4·00 $N\tau$ in.-lbs.

For (i) the image of an electric lamp filament is viewed in the film in such a way that the reflected ray is coincident with the incident one, so that their common direction gives the inclination of the normal to the surface of the film. For (ii) a steel needle-point, moistened with soap solution, is arranged to move about over the plate carrying the film, its distance therefrom being adjustable by means of a micrometer screw. The point is made to approach the film until the distortion of the image in the latter shows that contact has occurred. This position is found to be definite to ±0·001 inch in the measurement of the normal coordinate. For (iii) the films are blown up by running a known volume of water or soap solution into the apparatus from a pipette. The volume of the circular film may be calculated from the observed value of the inclination at its boundary, since its surface is a portion of a sphere, and hence the volume of the other film may be obtained by difference. The accuracy of the method was tested by direct experiments on wooden spars of I-section. The results are shown in the table. Column A shows the value of N obtained by twisting the spar, using the figure for torque obtained by the soap-films; columns B and C show the values of N found from round specimens cut from the thickest part of the two flanges, while column D gives the percentage difference between A and the mean of B and C.

COMPARISON OF SOAP-FILM RESULTS WITH THOSE OF DIRECT TORSION EXPERIMENTS.

Spar No.	Values of N (lbs. per sq. in. × 10^{-6}).			Difference (%).
	A	B	C	D
1	0·1091	0·1172	0·1063	2·5
2	0·0873	0·0640	0·0966	8·7
3	0·1156	0·1200	0·1151	1·7

When the contour lines of a film have been mapped, the torque may be found from them by integration. If the graphical work is done carefully, the value found in this way is rather more accurate than the one obtained by the volumetric method. The contour map is also a very useful method of showing the general nature of the stress distribution throughout the section in a clear and compact manner. The highly stressed parts show many lines bunched together, while few traverse the regions of low stress, and the direction of the resultant stress is shown by that of the contour at every point of the section. Furthermore, the map solves the torsion problem, not only for the boundary, but also for every section having the same shape as a contour line. In the Fig. is shown the half-section of a wooden wing spar. The close grouping of the lines near the internal radii, denoting high stress, is immediately evident. The projecting parts of the flange are lightly stressed, and contribute little to the torsional stiffness. The stress at the middle of the upper face is, however, considerable, being in fact next in order of magnitude below that of the radii. The stress near the middle of the web is practically constant, and equal to that in a very long rectangular section of the same thickness under the same twist. A further point of interest is that the "unstressed fibre" is very near the centre of the largest circle which can be inscribed in the section, while the three points of greatest stress are almost coincident with the points of contact of the circle. The paper concludes with a full account of numerous experiments on sections of all kinds which are amenable to analytical treatment for the purpose of testing the agreement between the values obtained by the soap-film method and by the use of the appropriate formula. A photograph is given of the actual apparatus employed.

J. W. T. W.

222. *Recurrent Tetrahedral Deformations and Intercontinental Torsions.* **B. K. Emerson.** (Am. Phil. Soc., Proc. 56. pp. 445–472, 1917.)—This paper contains a review of the book, "Die Entwickelung der Kontinente und ihrer Lebewelt," by Theodor Arldt, together with many of the author's own views on the controversial questions raised. The book itself is a ponderous volume, covering many diverse fields and containing an exceedingly great amount of painstaking and acute research. Just two-thirds of the book is devoted to a biography of the past and the present. After chapters on method comes a general survey of the distribution of plants and animals in the present and Cenozoic, in the Mesozoic and in the Paleozoic, with discussions of their evolution. The principal purpose of the study is to get all the light which the distribution and probable migrations of the different classes of animals and plants can throw upon the evolution of the continents. A first chapter takes a position adverse to the so-called "permanence of the continents." Only certain large portions of the great ocean seem to have been permanent. The second, or geological, section of the book begins with a condensed systematic discussion of the geological data for the determination of the outlines of the former continents, and a comparison of these data with those derived from the distribution of animals. These sections take up the larger part of the volume, and then four short chapters on Ice periods, Times of volcanic activity, Mountain formation, and Transgressions prepare for the central idea of the book, viz., the statement in tabular form of the cycles of the evolution of the earth and the explanation of the same as due to a succession of tetrahedral deformations producing broad, elevated continents and small oceans; and spherical recoveries, causing broad transgressions of the ocean with low lands. To this the present author has added statements regarding the changing carbonic acid content in the air and the changes in climate and evolution, drawn largely from Chamberlin's papers which are cited.

The law of least action demands, according to Arldt, that the somewhat rigid crustal portion of the earth keep in contact with the lessening interior with the least possible readjustment of its surface. As a tube collapses into a triangular prism, a shrinking sphere tends by the law of least action to collapse into a tetrahedron, or a tetrahedroid, *i.e.* a sphere marked by four equal and equidistant triangular projections; and the earth, with its three about equal and equidistant double continental masses triangular southward with three intervening depressed oceans triangular northward, its northern ocean and southern continent, with land everywhere antipodal to water, realises the tetrahedroid status remarkably. When repeatedly, in former geological ages, ocean waters separated Europe and Asia, the agreement with hypothesis was still more marked. Gravity observations and geodetic measurements agree therewith, even giving for Asia a larger tetrahedroid surface than for Europe, and many other geological homologies point in the same direction. The axis of the forming tetrahedroid chanced not to coincide with the axis of rotation, and the latter gradually shifted from near Behring Straits to its present position, which is one of stable rotational equilibrium. This happened in pre-Cambrian time. The development of the tetrahedral form from shrinkage would proceed but a little way, when rotation would tend to produce the spheroidal form. The tetrahedroid shape would be pushed beyond the strength of the material and collapse would ensue, with reassumption of a more spherical form. In a long period of rest the crust would be re-cemented and strengthened, and the continued escape of heat would then tend to develop the tetrahedroid again, and rotation would again restore the spheroid. The above is brought into connection with the six great geologic cycles as follows:—The solidified crust becomes, by interior shrinking, slightly tetrahedral. This involves elevation with glacial conditions, large continents, inner crustal tensions, foldings, fissuring, mountain-making, and outpouring of lava. Through this fissuring the crust becomes weakened, the tangential force of rotation becomes predominant, restoring the spheroid; great transgressions of the oceans then intervene while mountain-making and volcanic activity approach a minimum. In the relatively long time of submergence and quiet, the faults and fissures are sealed up by the circulating waters, and the earth becomes again rigid enough to permit the oncoming of a second period of tetrahedral deformation. The oceans are deepened and contracted, the continents elevated and enlarged with mountain-making, and this becomes again the cause of a glacial period and volcanic activity. This cycle is several times repeated. We are now in a period of deformation, as is shown by the marked tetrahedral features of the earth, the sinking of the Pacific coral region, the abundant volcanic and earthquake activity, and the just passed glacial period. Arldt assumes the nebular hypothesis and Arrhenius's theory of the condensed-gaseous condition of the earth's interior, and noting the unimportance of the present equator for the structure of the earth, and the great importance of the band going through the three Mediterraneans, *i.e.* the Mediterranean and the East and West Indian seas, he assumes that the equator once went parallel with this band and about 10° south of it, with the North Pole at Behring's Straits and the axis at right angles to the ecliptic. Then a band on either side of this equator including "the zone of the intercontinental seas" or of the above three Mediterraneans, because of the powerful tidal influence in the early ages, would be a zone of distortion and rupturing during the crust-forming period and of weakness since. This is Lowthian Green's twinning plane. It is shown how the hypothesis of a tetrahedral earth can be utilised in the fundamental explanations of the past conditions of the earth, and this adds to the strength of the hypothesis. Wholly novel is the suggestion that the tetrahedroid may have alternated repeatedly with the spheroid, thus making the earth a composite photograph of several tetrahedra.

The reviewer here presents (1) a different explanation of the chains in the Mediterranean zone as due to northward flow (rather than to thrust from the sinking of the Mediterranean), and (2) a new exposition of the torsional movements, which differ from that in the book under review. A map of the world is included showing tetrahedral deformation. The migration of the poles is dealt with at some length, attention being called to the consideration that the tetrahedral hypothesis does not stand or fall with the hypothesis of their suggested movement. In accordance with the idea of multiple-working hypotheses, the author examines and compares the other current theories concerning the genesis of continents to ascertain whether the tetrahedral tendency may not coexist with all other agencies of deformation and sometimes partially control the result. The postulates of the planetesimal hypothesis are found to be distinctly favourable to the tetrahedral theory. Chamberlin's work is discussed at some length, and the tetrahedral hypothesis is shown to be a welcome introduction or preliminary to Chamberlin's suggestion of diastrophism as the foundation of correlation, since it gives a cause for a rhythmical recurrence of short periods of diastrophism with long intervening periods of quiescence. In harmony with this hypothesis is the remarkable generalisation of White and Knowlton, that a uniform warm humid climate extending beyond the polar circles has been the rule from early paleozoic, interrupted by relatively short periods of climatic extremes when great glacial areas coexist with a torrid zone. Chamberlin's work gives a more nebular trend to the planetesimal hypothesis, and develops the thesis that the major influence in producing the larger inequalities of the earth's surface has been the variation in the rate of rotation of the earth, thereby proposing a supplement or substitute for the tetrahedral hypothesis. The two theories, namely, tetrahedral and rotational, are critically examined at great length. The idea of a spherical recovery and extensive transgression and exceptionally equable climate far poleward would take away largely the need from the biological side of many assumed continental connections across the deep oceans as bridges for migrations. Mathew's article on "Climate and Evolution" [see N.Y. Acad. Sci., Ann. vol. 24. pp. 171–318], which is quoted and abstracted in the paper, brought full confirmation of the above suggestion and a strong condemnation of the indiscriminating bridge-building theory. Finally, the reviewer concludes by stating that there is a certain threefold hierarchy in earth-movements—orogenic or mountain-making; epeirogenic or plateau-making; tetrahedrogenic or continent-making.

H. H. Ho.

223. *The Discharge of Gases under High Pressures.* **L. Hartshorn.** (Roy. Soc., Proc. 94. pp. 155–165, Jan. 1, 1918.)—De St. Venant and Wentzel in 1839 stated, as a result of their experiments, that when gas was discharged through an orifice from a vessel in which the pressure was p_0 into one in which the pressure was p_1, then the rate of discharge was sensibly constant from $p_1 = 0$ upwards to $p_1 = 0{\cdot}3p_0$ or $0{\cdot}4p_0$, but then, as p_1 further increases, the discharge falls off, slowly at first, afterwards with great rapidity. In 1885 O. Reynolds quoted some experiments which seemed to show that the flow remained constant from $p_1 = 0{\cdot}50p_0$ or $0{\cdot}53p_0$. He explained this by pointing out that the max. "reduced velocity" occurs when the actual velocity coincides with that of sound under the conditions then prevailing, as then the effect of a further reduction of pressure in the recipient vessel cannot be propagated backwards against the stream. If $\gamma = 1{\cdot}408$, this argument suggests that for a nozzle ending abruptly at the narrowest part, the discharge reaches a maximum when the pressure in the recipient vessel falls to $0{\cdot}527p_0$, and then remains constant. Rayleigh pointed out [Abs. 1100 (1916)] the importance of examining with more accuracy than has hitherto been obtained the extent to which this constancy of flow for different values of p_1 is true, and the present paper contains a record of work undertaken on this suggestion. Full details of the apparatus used are given, together with an exhaustive account of the experiments performed. Several diagrams and curves are included. From the curves it follows that the discharge is independent of the pressure in the receiving vessel when this is less than a certain fraction of that in the discharging vessel. The experiments also show that the theoretical value of the critical pressure below which the flow from a convergent nozzle remains constant, namely, $0{\cdot}527p_0$, cannot be accepted as applying to all nozzles, or even approximately so. In some cases the value is as low as $0{\cdot}2p_0$, and in others as great as $0{\cdot}8p_0$. The value $0{\cdot}2p_0$ holds very approximately, however, for all the nozzles tried except the divergent ones. Those ending in divergent cones all have higher values which increase as the cone angles decrease from large values down to about 3°. In this case the critical pressure is about $0{\cdot}8p_0$, and, with further decrease, the value of the critical pressure seems to decrease: *e.g.* for an angle of 0·7° it is about $0{\cdot}4p_0$, and when the angle becomes zero, *i.e.* for a parallel hole, a value of $0{\cdot}2p_0$ was obtained. Nozzles of large diameter were tried with a view to finding whether the foregoing results might be of practical importance in connection with turbine nozzles. It was found that the effects were practically the same as with smaller nozzles of the same shape. H. H. Ho.

224. *Influence of Air-resistance on the Translation of Moving Bodies possessing Rotatory Motions.* **Z. Carrière.** (J. de Physique, 5. pp. 237–248, July–Aug.–Sept., 1916.)—The paper deals with the case of a conical pendulum rotating about its suspension wire. Section 1 contains a very detailed

description of the apparatus with illustrative diagrams. The cylindrical bob of the pendulum, while itself in rotation, acquires an elliptical movement. Section 2 of the paper deals with the sense of the velocity of rotation of the major axis of the ellipse and its dependence on the angular velocity of the bob; following this, the circulatory movement of the ellipse itself and its relationship to the angular velocity of the bob is considered. Section 3 contains the data of the various motions. In Section 4 the discussion of the previous relationships is continued. Section 5 deals with the influence of the dimensions, nature and weight of the bob. Section 6 considers various special cases of the circulatory elliptical movement, and, finally, Section 7 discusses the causes of the various phenomena. H. H. Ho.

225. *Fundamental Kinematics of a Physical Wave of Elementary Vibration Form.* III. **K. Uller.** (Phys. Zeits. 18. pp. 548–550, Nov. 15, 1917.)—Every theory dealing with a physical complex relating to space and time can be expressed by field equations which connect the changes between these respective physical magnitudes. The system of field equations also gives the general case for the origin of waves at their source, and the passage of these waves into regions which are free from disturbance. The essential feature is that once the waves have been generated, they conform to a special wave surface, and behave as an entity analogous to a static field. In this paper the author investigates the form of the wave surface. The cases of stationary and non-stationary are first dealt with, followed by a discussion of the kinematical expression for the interference principle applied to waves of elementary vibration form. The next section deals at some length, using vector analysis, with the equation system for electromagnetic waves in ordinary isotropic bodies. Finally the equation system of the temperature wave in ordinary isotropic and solid bodies receives attention. [See Abs. 360 (1917).] H. H. Ho.

226. *Characteristic Frequency and Atomic Number.* **H. S. Allen.** (Roy. Soc., Proc. 94. pp. 100–111, Dec. 1, 1917.)—From a consideration of the empirical formulæ of Moseley, Nernst, Lindemann, Griffiths, Debye, and others, the author arrives at the striking conclusion that all these relations may be summarised in the formula $N\nu = n\nu_E$. Here N and ν have the usual significance, as applied by Moseley: n is an integer and ν_E is a constant or fundamental frequency.

Multiplying each side of the equation by h, we obtain $Nh\nu = nh\nu_E$, or, since $h\nu = eV$, $NeV = neV_E$. But Ne is the charge E on the nucleus; hence $EV - neV_E = 0$.

This suggests that in the limiting conditions which arise in all physical phenomena under discussion, we have to deal with a minimum value of the energy of a system comprising the nucleus and a certain number of electrons. A. B. W.

227. *Atomic Frequency and Atomic Number-frequency Formulæ with Empirical Constants.* **H. S. Allen.** (Phil. Mag. 34. pp. 478–487, Dec., 1917.)—A relation between the characteristic frequency of an element in the solid state and the atomic number is to be expected on theoretical grounds. In another paper [see preceding Abs.] the author established such a relation: $N\nu = n\nu_A$. N is Moseley's atomic number for an element, and ν the characteristic frequency deduced from specific heat determinations in the solid state; "n" is a whole number, and ν_A a constant having the value $21{\cdot}8 \times 10^{12}$ sec.$^{-1}$.

The formulæ of Blom, Einstein, Lindemann, Alterthum, Grüneisen, and Debye are considered. The values of $N\nu$, calculated from the various formulæ, are included in a table for all the known elements.

The author concludes that the value "n" in the formula $N\nu = n\nu_A$, varies in a periodic way with the atomic number, but he defers discussion of the dependence of the value of n on the place in the Periodic table. A. B. W.

228. *Electronic Frequency and Atomic Number.* **H. S. Allen.** (Phil. Mag. 34. pp. 488–496, Dec., 1917.)—In a paper on the relation between atomic frequency and atomic number [see preceding Abs.] the author has shown that the product of Moseley's atomic number, N, and the characteristic frequency, ν, for an element in the solid state can be expressed in the form $N\nu = n\nu_A$. $\nu_A = 21{\cdot}3 \times 10^{12}$ sec.$^{-1}$. The object of the present paper is to show that a similar relation holds for certain electronic frequencies, but when the vibration of an electron is in question it is necessary to replace the constant ν_A by the fundamental electronic frequency $\nu_E = 3{\cdot}289 \times 10^{15}$ sec.$^{-1}$, which is Rydberg's constant in spectral series usually expressed as the wave-number 109679·22. The relation then takes the form $N\nu = n\nu_A$ or $N\nu = (n + \frac{1}{2})\nu_E$. This relation is found to hold in connection with: (1) the maximum of the photoelectric effect, (2) the threshold frequency, or long wave-length limit, of the photoelectric effect, (3) the ionisation potential of a gas, (4) the "electron affinity" deduced from thermionic measurements.

The relation is discussed from the standpoint of the quantum theory.

A. B. W.

229. *Crystal Structure.* **A. C. Crehore.** (Phys. Rev. 10. pp. 432–460, Nov., 1917.)—The results of the author's previous investigations [see Abs. 1189 (1915) and 1299 (1917)] of the problem of finding the average mechanical force between two electrical charges in uniform circular motion, are here applied to twenty cubic crystals. Equilibrium conditions are determined for several forms of space-lattice, the only unknown quantities in the equations obtained being $\Sigma_p a^2$ and $\Sigma_p(a\beta)$, summed for each electron in the atom concerned, p being the number of electrons in the atom, a the radius of the electron's orbit, and β the ratio of its velocity to that of light. The original Thomson equations are employed, their validity at the distances concerned being assumed to be justified by the concordances obtained in his former paper [Abs. 1299 (1917)] between deductions from these equations and from his empirically derived modification of the Lorentz equations. Some further hypothesis is required before either the relative or absolute values of a and β can be found. The assumption of equal moment of momentum for each and every electron employed, for want of a better one, has been abandoned, as it demanded double, instead of single, atoms at every point of the space-lattice, and the spectrometer observations disprove this. But it appeared in the paper above mentioned that gravitational attractions between bodies at a distance is proportional to the product of the sums of the squares of the speeds of the electrons summed over each body separately. Since the weight of an atom is constant, it therefore seems reasonable to assume that the sum of the squares of the speeds of the electrons within it is constant. The assumption made therefore is that $\Sigma_p\beta^2$ is constant for any one atom. Now the same atom may take several different forms without altering $\Sigma_p\beta^2$. Consequently the moment of momentum may have different values corresponding to changes in the radii. The values of $\Sigma_p a^2$, $\Sigma_p(a\beta)$, and $\Sigma_p\beta^2$ are

found for each of twenty different atoms that enter into the twenty different crystals considered, and are plotted as curves against the atomic number in terms of a constant multiplier. By the aid of the author's previous determination [Abs. 1189 (1915)] of the speed of electrons in rings of 4 and 8 electrons respectively, the constants may be determined and the above expression evaluated for any atom in absolute measure. This is worked out for the carbon atom in two forms—with 12 electrons and 6 electrons respectively. The values of the constants do not greatly differ in the two supposed forms of carbon, and the results have been used to obtain an absolute scale. Two secondary curves are given as alternative values of $\Sigma_p a^2$ for some atoms. The curve for $\Sigma_p(a\beta)$ is very nearly a straight line for the atomic numbers above 40, zirconium, but does not pass through the origin. $\Sigma_p(a\beta)/N$, where N is the atomic number, giving the average moment of momentum per electron, gradually increases with N. The curve for the mean angular velocity shows a decrease in the frequency as N increases, the frequency becoming very great for the highest elements. If we identify the frequencies of revolution of the electrons in their orbits with optical frequencies, according to Bohr's theory, the radii of the orbits will come out much greater than indicated by the average values of the frequencies, which might be due to a few "valency" electrons, as is otherwise suggested, circulating in large orbits with smaller frequencies. If this be so, the electromagnetic forces as developed in infinite series cannot be applied to them, because the force-series is no longer convergent when the distance between the centre is comparable with the diameter. A knowledge of the absolute values leads to a determination of the constant in the equation for the weight of an atom, from which the value of β for the average electron of the earth is found to be 0·00765, which leads to a speculation that the interior of the earth may consist of hydrogen, or, at any rate, the very lightest of the known elements, and the author remarks that this suggests for the first time a possibility of finding the kind of elements that make up the interior of the earth and possibly other heavenly bodies. An appendix is devoted to the derivation of the force equation from the cubic space-lattice formation, and to a consideration of the error, found to be appreciable but not excessively great, made by neglecting the more distant atoms in the crystal than those included in a cube edge four times the elementary cube. G. W. DE T.

230. *The Brownian Movement of Single Particles.* **R. Fürth.** (Ann. d. Physik, 53. 11. pp. 117–213, Nov. 27, 1917.)—This paper contains an extensive review of the Brownian movement of single particles, the subject being considered both theoretically and experimentally. The first part deals with the Brownian movement of particles suspended in a liquid; the particles investigated move unrestrictedly in all directions, either under the influence of gravity or not. Smoluchowski's principle is here employed [see Abs. 1609 (1915)]. The second part considers how far the motion of the particles may be modified by a rigid partition; how the latter phenomena may be utilised for obtaining an absolute determination of the "Loschmidt number" on the one hand, and how to employ the data obtained at concentration changes for application to the case of single particles on the other hand. In Part I a mathematical investigation precedes a very detailed account of the experimental methods adopted to establish the theoretical results. This section is accompanied by eight tables and two curves. Part II, dealing with the Brownian movement of a particle in the vicinity of a rigid partition, commences with a discussion of experimental details. Following this comes a

mathematical and experimental investigation of sedimentation, two tables of comparative results (theoretical and observed) being given. The final section deals with the phenomena for concentration changes, with two tables of comparative data. H. H. Ho.

231. *The Velocity of Gravitational Propagation. Observations upon a Communication by P. Gerber.* **M. v. Laue.** (Ann. d. Physik, 53. 11. pp. 214–216, Nov. 27, 1917.)—Although from the astronomical side it has been shown that the expression proposed by Gerber [Abs. 718 (1917)] for the gravitational potential does not lead on application to Gerber's equations of motion, and in consequence cannot lead to his formula for perihelion motion, yet the present author proposes to examine how far the general considerations constitute a connection between the planetary orbits and the propagation of gravitational effect. The author commences by a discussion of the mathematical expression for the gravitational potential, after which Gerber's hypothesis is shown to be incompatible with a finite velocity of propagation. Comparison is made with Weber's fundamental hypothesis of electrodynamics, which latter is similar in many respects to Gerber's gravitational theory. The paper concludes with a discussion of the effects due to planetary motion.
H. H. Ho.

232. *The Einstein Gravitational Theory and the Problem of Matter.* **G. Mie.** (Phys. Zeits. 18. pp. 551–556, Nov. 15, and pp. 596–602, Dec. 15, 1917.) —This article gives the main parts of the author's three Wolfskehl Lectures, certain parts of the latter having been recast and extended. L. H. W.

233. *The Production of Scientific Knowledge.* **C. E. K. Mees.** (Nature, 100. pp. 355–358, Jan. 3, 1918. Paper read before the Optical Soc. of America, Oct., 1917.)—Deals in turn with (1) Research work, (2) the Classification of Scientific Knowledge, and (3) the Utilisation of Scientific Knowledge.
L. H. W.

234. *The Diurnal Variation of Wind with Height.* **L. Dunoyer** and **G. Reboul.** (Comptes Rendus, 165. pp. 1068–1071, Dec. 24, 1917.)—Results of observations of pilot balloons in France carried out at all hours of the day and night, show that at heights of from 200 to 800 m. the diurnal variation of wind velocity shows a pronounced maximum during the night, especially when the surface wind is light, and coming from the east. The effect is masked by the influence of depressions; and it is therefore not well shown with westerly winds. R. C.

235. *Relation between Barometric Pressure and Water-level in a Well at Richmond.* **E. G. Bilham.** (Roy. Soc., Proc. 94. pp. 165–181, Jan. 1, 1918.) —The results obtained are: (1) At all seasons of the year the water-level is sensitive to changes of pressure, a rise of pressure being associated with a fall of water-level, and *vice versa.* (2) Within certain limits the change of level is proportional to the change of pressure producing it. (3) The magnitude of the change of level produced by a given change of pressure increases rapidly as the subsoil water-level rises. (4) There is no appreciable lag in the response of the water-level to changes of pressure.

Two suggestions are put forward as possible explanations of this phenomenon: (*a*) The well may be regarded as the open end of a manometer connected at the other end to a closed reservoir, which is represented by the air contained in the interstices of the soil above the water-level. (*b*) The effect may be due to a differential action on the deflection of the earth's crust and of the underground water surface produced by change of barometric pressure. J. S. Di.

236. *Meteorological Observations on the "Carnegie" during the Sub-Antarctic Cruise, Dec.* 6, 1915, *to April* 1, 1916. **J. P. Ault.** (Terrest. Magn. 22. pp. 183–189, Dec., 1917.)—The readings taken during this cruise round the globe between latitudes 50° and 60° S. are contemporaneous with those made by the two parties of Shackleton's expedition on the Antarctic continent. The observations here summarised consist of daily records of weather, wind direction with extremes of force, barometric pressure, relative humidity, air and sea temperature, and ocean current measurements. The lat. and long. for noon of each day are also given. J. S. Di.

237. *Phenomena Connected with Turbulence in the Lower Atmosphere.* **G. I. Taylor.** (Roy. Soc., Proc. 94. pp. 137–155, Jan. 1, 1918.)—The power possessed by the air in virtue of its turbulence, of transmitting heat and momentum may be represented by the symbol K, where K is proportional to the vertical velocity in the eddies and to the scale of the turbulence. A definition of K has been given in an earlier paper [Abs. 536 (1915)] and its value was there found to be $0{\cdot}3 \times 10^4$ in c.g.s. units, this figure being obtained from measurements of the change of temperature with height over the sea under conditions in which the turbulence would be very small. Greater turbulence would naturally be expected over the land, and the value of K for the neighbourhood of Paris is now worked out from figures which give the diurnal variation of temperature at different heights on the Eiffel Tower. The mean value for the year is found to be 10×10^4, very much larger than that over the sea. There appears to be no indication of an annual variation close to the ground, but K decreases with height in winter, and increases with height in summer. This is ascribed to the more nearly adiabatic temperature gradient which occurs in summer—a condition favourable to the development of large values of K. The value close to the ground is nearly independent of the temperature gradient, and is governed almost entirely by the wind velocity.

With a given gradient wind, the wind at levels down to the ground will be dependent on the value of K. Assuming a uniform fluctuation of K from a maximum at mid-day to a minimum at midnight, the form of the diurnal variation of wind velocity is calculated for different heights, and it is found that near the ground the velocity will show a maximum at mid-day and a minimum at night. At a certain distance up there will be two equal maxima, at mid-day and midnight with minima between, and at a still greater height a maximum at midnight and a minimum at mid-day. Some recent experiments on the diurnal variation of wind velocity at different heights by Hellmann have shown that these conditions do actually exist. Further, if values of K based on the Eiffel Tower temperature observations are used, reasonably good quantitative agreement is found between the height at which the type of diurnal variation of velocity should change from one form to the other as deduced by Taylor's theory, and that at which it actually does change. This agreement provides strong confirmation for the idea that both heat and momentum are conveyed through the air by the same agency, namely, eddy conductivity.

This theory to explain the diurnal variation of wind velocity in the lower layers seems more satisfactory than that put forward some time ago by Espy and Köppen, which fails to account for the results found by Hellmann. J. S. Di.

238. *The Vertical Distribution of dissolved Oxygen and the Precipitation by Salt Water in certain Tidal Areas.* **J. W. Sale** and **W. W. Skinner.** (Frank. Inst., J. 184. pp. 837–848, Dec., 1917.)—Birge and Juday have shown that dissolved oxygen is deficient in the lower layers of water of 129 inland lakes of Wisconsin, due to thermal stratification of the water and subsequent depletion of the oxygen in the colder layers by the process of respiration of plants and animals, by the direct oxidation of dead organic matter, and by the decomposition which results from the action of bacteria. Data obtained by the authors also show that less dissolved oxygen is present in the water near the bottom of the Potomac Estuary and of portions of Chesapeake Bay than in the surface water, apparently due to the under-run of salt water present in those waters and the subsequent depletion of the oxygen in the lower layers as indicated by Birge and Juday. Maximum turbidity of two tidal rivers has also been found to occur in those regions where salt water first appears. The two phenomena of depleted dissolved oxygen content and of max. turbidity at the junction of fresh and salt water are related in that the sedimentation caused by the salt water is a contributing factor in the depletion of the oxygen of the lower layers of water. These data are of particular interest because of the possible relation which the dissolved oxygen content bears to the mortality of fish and shellfish, reported as occurring at the mouth of the Potomac and of other rivers flowing into Chesapeake Bay and in other tidal waters. It is thought that the dissolved oxygen content of those waters may have a profound influence on fish life, particularly on the migration of fish in those regions. The depletion of oxygen was found to be greatest in September. The precipitation and sedimentation of matter in tidal areas by sea-water have been presented in graphic form. A study of the relations of the dissolved oxygen curves to the chlorine curves shows that when an under-run of salt water is present the dissolved oxygen curves for the deep samples are considerably lower than the curves for the surface samples, showing less dissolved oxygen in the deep samples than in those from the surface. When an under-run of salt water is absent, the curves are closer together. The Potomac Estuary may be regarded as homothermous. H. H. Ho.

239. *Nitrogen, Chlorine, and Sulphates in Rain and Snow.* **E. L. Peck.** (Chem. News, 116. pp. 283–284, Dec. 14, 1917.)—Continuing the observations of Artis at Cornell College, the author deals with 33 precipitations (15·86 in.) of rain and 8 precipitations (22 in.) of snow (equivalent to 17 in. of rain) in the period Oct. 20, 1916, to June 8, 1917. The substances determined are sulphate (from 4 to 37 parts per million in a precipitation), nitrate (0·1 to 0·35 part), nitrite (0·0005 to 0·2), nitrogen in free ammonia (up to 0·87); nitrogen in albuminoid ammonia (up to 0·388), and chlorine (2·84 to 18·62); the chlorine content was the most constant, being 7·1 parts in 20 cases. H. B.

240. *Eruption of the Volcano Quetzaltepeque and the Destructive Earthquake of San Salvador (June–July 1917).* **A. Lacroix.** (Comptes Rendus, 165. pp. 1077–1082, Dec. 31, 1917.)—Earthquakes in San Salvador are of common occurrence, but their connection with volcanic activity has not been suspected hitherto. The author here correlates the various data available for the elucidation of the problem. A detailed geological description of the district is first given, followed by a most vivid account of the volcanic eruption on June 7th. The lava emitted was found to possess a basaltic character, while the abundant sublimations which occurred were composed for the most part of chloride and sulphate of ammonia associated with a little sodium chloride.

The mechanism of the eruption was found to be of the Etna type. The accompanying earth-movements caused destruction within a radius of 25 km. This eruption not only exhibits the case of revival of a volcano formerly considered extinct, but furnishes precise data for the open discussion of the relationship between seismic disturbance and volcanic activity in this region. The data are exceedingly valuable inasmuch as previous destructions of San Salvador by earthquake had apparently no connection with volcanic activity. The latter conclusion has evidently to be seriously revised. H. H. Ho.

241. *The Coral-reef Problem and the Evidence of the Funafuti Borings.* **E. W. Skeats.** (Am. J. Sci. 45. pp. 81–90, Feb., 1918.)—It is not possible here to do more than quote the author's summary, as follows:—

The conclusion is reached, based on the examination of the organisms and textures from the bore and the submarine contours of the island of Funafuti, that the only hypothesis of origin capable of correlating and accounting for all these facts is the subsidence theory of Darwin. Supporting evidence of the shallow-water origin of all the material and therefore subsidence of the land will be brought forward in a succeeding paper dealing with the formation of dolomite and its distribution among coral and other limestones.

The conclusions to be drawn from this summarised statement of observations, both positive and negative, seem to the author to be clear, namely, that the whole material of the atoll from the surface down to the bottom of the core at 1114 ft. 6 in. is essentially homogeneous in origin and organisms, and all of it was formed in shallow water. This necessarily involves either a subsidence of the land to the extent of 1114 ft., or possibly while the bulk of the material was formed during subsidence, a small portion may be due to growth during a post-glacial rise in sea-level. L. H. W.

242. *Geographical Conditions for Total Solar Eclipse,* 1919 *May* 28–29. **A. R. Hinks.** (Roy. Astron. Soc., M.N. 78. pp. 79–82, Nov., 1917.)—In general the conditions are unfavourable, as the greater part of the track lies in the two largest tropical river basins, the Amazon and the Congo. Possible stations would be Ceará (Brazil), Principe Island, near Libreville (French Congo), and the western escarpment of Lake Tanganyika. Details are given of available facilities. The most favourable station for clear sky appears to be at Baudouinville, on Lake Tanganyika, where there is an establishment belonging to the White Fathers at an altitude of 1200 m. above sea-level.
C. P. B.

243. *Absorption of Water on Moon and Planets.* **A. Véronnet.** (Comptes Rendus, 165. pp. 629–632, Nov. 5, 1917.)—Taking account of the determinations of occluded moisture in terrestrial granite as indicating the amount that may be absorbed from superficial or atmospheric sources at the time of congealing after fusion, estimates are made of the probable extents of the aqueous portions of the initial atmospheres of the moon and planets. In the case of mercury it is thought the results indicate that the water is still all in the form of vapour, no condensation being yet possible owing to the high surface temperature. C. P. B.

244. *Spectrum of Wolf's Comet.* **V. M. Slipher.** (Popular Astron. Nov., 1917. Nature, 100. p. 332, Dec. 27, 1917. Abstract.)—Photographs of the spectrum of Wolf's Comet were obtained at Flagstaff, Arizona, on 1917 Aug. 25 and 26. The spectrum was chiefly continuous, with traces of the cyanogen band at 3883, and the hydrocarbon band at 4737. Although the spectrum was too narrow to show the solar lines; it is thought that the comet was shining almost entirely by reflected sunlight. C. P. B.

245. *Atmospheric Refraction.* **W. T. Neill.** (Astron. J. 31. pp. 9–16, Nov. 26, 1917.)—Fundamental equations of the law of refraction are deduced from first principles, the method being similar to that of Cassini, but instead of the change of direction of the path of a ray of light taking place on a definite outer surface of the homogeneous atmosphere, it is supposed to take place on imaginary concentric surfaces, the radii of which increase with the altitude. A table of refractions is given for each degree of zenith distance from 0° to 90°, with appropriate corrections for temperature and pressure. C. P. B.

246. *Parallax of Faint Proper-motion Star near α Centauri.* **R. Innes.** (Union Observat. S. Africa, Circ. No. 40. pp. 331–338, Sept. 3, 1917.)—Several determinations of the parallax of a faint star [RA = 14h. 22m. 55s. Decl. = − 62° 15·2′] near α Centauri indicate that the star may be the nearest known star to the solar system, and it is suggested that it be named *Proxima Centaurus.* The mean value of the parallax is given as 0·784″. C. P. B.

247. *Principle of Relativity and Displacement of Fraunhofer Lines.* **C. E. St. John.** (Mt. Wilson Solar Observat., Contrib. No. 138. Astrophys. J. 46. pp. 249–265, Nov., 1917.)—Exhaustive tests have been made to detect any evidence on the question that, according to Einstein's equivalence principle of generalised relativity, the lines in solar and stellar spectra should be displaced to the red when referred to corresponding terrestrial lines. Lines of the band spectrum of nitrogen (cyanogen) have been used in spectra of great dispersion, and the conclusion is that within the limits of error there is no evidence of displacement to longer wave-length, either at the centre or limb of the sun, of the order of magnitude required by the relativity principle. There is a limb-effect not due to motion, in which pressure, level, and line-intensity appear to be involved in varying degrees for different elements. C. P. B.

248. *Light-curve of V Bootis.* **G. B. Lacchini.** (Soc. Spettroscop. Ital., Mem. 6. pp. 81–84, May–June, 1917.)—The author's light-curve is based on 138 observations extending from 1912 March 8 to 1917 Feb. 28 (6 maxima and 7 minima). This variable is notable for the varied shape of its light-curve at maxima and minima. Thus at maxima 37 and 38 the light remained nearly constant for about 90 days (mag. 7·95, 8·43 respectively); at the maxima 40 and 41 the light-variation was continuous and the curve pointed; again, the minima show sometimes peaked (corresponding to flattened curve of maxima) and sometimes obtuse (corresponding to pointed curve of maxima) curves (mag. between 9·8 and 11·1). The mean value for the periodicity works out at 263·8 days. L. H. W.

249. *Observations of Mira Ceti.* **G. B. Lacchini.** (Soc. Spettroscop. Ital., Mem. 6. pp. 131–133, Sept.–Oct., 1917.)—The author gives light-curves for this variable for the interval 1914 July 14 to 1917 March 20. The period, taking into consideration the dates of maxima, minima, and time where the curve shows a magnitude of 6·5, works out as a mean at 330·4 days. Tabulated data of the observations are given. L. H. W.

250. *Parallax of P Ophiuchi.* **J. C. Solá.** (Comptes Rendus, 165. pp. 553–555, Oct. 22, 1917.)—From stereoscopic measurements on 9 photo-

graphs taken with the Astrographic Equatorial at Barcelona during 1917, the parallax of this star (whose remarkably large proper motion was recently discovered by Barnard) is estimated to be 0·418″. C. P. B.

251. *Equations of Radiative Transfer of Energy.* **J. H. Jeans.** (Roy. Astron. Soc., M.N. 78. pp. 28–36, Nov., 1917.)—An independent derivation is made of the laws of radiative transfer of energy in stellar masses, in part criticism of two papers by Eddington with which the present author is not in agreement [Abs. 893, 1258 (1917)].

252. *Evolution and Radiation of Gaseous Stars.* **J. H. Jeans.** (Roy. Astron. Soc., M.N. 78. pp. 36–47, Nov., 1917.)—An outline is given of the investigation of the physical changes undergone as a mass of gas contracts under its own gravitation. The analysis leads to the conception of visible giant stars being only the end of a long series of configurations of which the earlier members, being at much lower temperatures, will radiate only heat. The total emission of energy of these pre-giant stars will be very much less than that of the giant stars, so that a star may exist as a visible giant for only a small fraction of its life, and in a cluster of stars of all ages a large proportion of the stars may be dark. C. P. B.

253. *Physical Conditions in Interior of a Star.* **A. S. Eddington.** (Scientia, Jan., 1918. Nature, 100. pp. 372–373, Jan. 10, 1918. Abstract.)—In a popular account of the results of recent mathematical analyses it is shown that following the work of Hertzsprung and Russell, many well-known stars are regarded as being in a highly diffuse state, and when such bodies contract under their own gravitation they will rise in temperature until they cease to approximate to perfectly gaseous conditions. Eddington modifies Love's theory by introducing the factor of radiation-pressure.
C. P. B.

254. *Radial Velocities of Star Clusters.* **V. M. Slipher.** (Roy. Astron. Soc. Canada, J. 11. p. 335, Oct., 1917. Nature, 100. p. 318, Dec. 20, 1917. Abstract.)—Observations on the spectra of ten star clusters show that the radial velocities range from − 410 to + 225 km./sec., the high velocities suggesting that these clusters are distinct from our stellar universe.
C. P. B.

255. *Parallax of Ring Nebula in Lyra.* **A. van Maanen.** (Popular Astron. 25. p. 630, 1917. Nature, 100. p. 318, Dec. 20, 1917. Abstract.)—A determination of the parallax of the central star in the Ring Nebula in Lyra has been made from photographs taken with the 60-in. reflector at Mount Wilson, the result being a relative parallax of + 0·002″. C. P. B.

256. *Cusped Orbit of Dr. Hill.* **R. Moritz.** (Roy. Astron. Soc., M.N. 78. pp. 48–58, Nov., 1917.)—Details are given of the application of Cowell's method of mechanical quadratures to the investigation of Hill's cusped orbit, the latter being confirmed by the new method, which is shown to be much more expeditious. It is noted that the method could be applied to those looped orbits shown by Poincaré to succeed the case of the cusped orbit, when the ratio of the mean motions is still further reduced. C. P. B.

LIGHT.

257. *Triple Cemented Telescope Objectives.* **T. Smith** and **[Miss] A. B. Dale.** (Phys. Soc., Proc. 30. pp. 21–30, Dec., 1917.)—The paper describes the four series of triple cemented thin telescopic objectives which can be made from two kinds of glass, and determines their construction when first-order spherical aberration and coma are eliminated. The second-order spherical aberration and coma are then calculated, and the former found to be of the same sign for all optical glasses when the surfaces are spherical. The best standard attainable varies very little over a considerable range of glasses. Diagrams show the variations in the curvatures as the glasses are varied for refractive index and dispersion. Contrary to the general belief, it is found that the objectives with least second-order aberrations (absolute values) are not those with the least curvatures for their refracting surfaces. AUTHOR.

258. *On a Class of Multiple Thin Objectives.* **T. Smith.** (Phys. Soc., Proc. 30. pp. 31–61; Disc., 61–62, Dec., 1917.)—The objectives dealt with are cemented combinations of several thin lenses. Two kinds of glass only are employed, the odd elements being of one kind, say, crown, and the even elements of the other kind, flint. Such lenses may be regarded as combinations of achromatic cemented doublets, and formulæ are found for the aberration coefficients of such lenses in terms of those of a standard doublet when the geometrical conditions for the absence of air-gaps between the components are satisfied. Generally speaking, the results reached are that the outer surfaces are concerned with coma, and the internal surfaces with spherical aberration. In all cases the determination of a system to satisfy given conditions involves only the solution of a quadratic equation, and an algebraic method thus effects a solution in a fraction of the time involved in a trigonometrical investigation. Chromatic differences of first order aberrations are easily determined.

The application of the method is illustrated by a series of quadruple objectives which satisfy the ordinary conditions for telescope objectives. Diagrams show the variation of the curvatures with the different forms, the magnitude of the second-order spherical aberration, and the chromatic differences of first order aberrations. AUTHOR.

259. *Humidity Correction Factor for Pentane Lamp.* **K. Takatsu** and **M. Tanaka.** (Electro-Techn. Laborat., Dept. of Communications, Tōkyō, Oct., 1917. Abstract of Report No. 12.)—Describes experiments on a 10-c.p. Harcourt Pentane Lamp certified by the National Physical Laboratory, compared with a 16-c.p. Ediswan-Fleming carbon-filament standard. The humidity was measured with an Assmann ventilated hygrometer and the observed c.p. of the pentane lamp was corrected for barometric pressure, using a correction factor of —0·0008. As a result of 162 observations the value of the humidity correction factor was found to be + 0·00638, which agrees better with Paterson and Dudding's value of 0·0063 [see Abs. 1026 (1915)] than with Rosa and Crittenden's of 0·0057 [Abs. 304 (1915)]. It is suggested that the hood and ventilating duct used at the Bureau of Standards may play some part in causing the difference between the values found at the Bureau and at the N.P.L., as the hood affects the c.p. at the same barometric pressure and humidity, and it is possible that the effect would not be the same at different humidities. J. W. T. W.

V.2
191

260. *The Diffraction Waves in Kirchhoff's Theory of Diffraction Phenomena.* **A. Rubinowicz.** (Ann. d. Physik, 53. 12. pp. 257–278, Dec. 14, 1917.)—The paper is divided into 8 sections and is introduced by an historical survey of the work done on diffraction phenomena. Section I deals with the transformation of Kirchhoff's diffraction integral. In II the structure of the elementary diffraction wave is considered. Analytical extensions of Kirchhoff's solution are investigated in III. In IV the application of the Kirchhoff solution to the black screen is considered; also the diffraction at a perfectly bright screen. Radiation conditions and their interpretation occupy V. The Kirchhoff solution for an infinite semi-plane is given in VI. In VII Sommerfeld's diffraction problem is reviewed, and in VIII a comparison between the two theories is made; in this section the elementary diffraction wave for Sommerfeld's solution is also considered.

The paper is mathematical throughout. H. H. Ho.

261. *Limit of Interference in the Fabry-Perot Interferometer.* **M. N. Saha.** (Phys. Rev. 10. pp. 782–786, Dec., 1917.)—The theory of the Fabry-Perot interferometer has been worked out by Lippich, Rayleigh, and Schönrock [Abs. 826 (1907)]. They have shown that when the pressure is small, the critical distance D (or the limit of interference) is connected by the following formula with the wave-length (λ) of the light, the temperature (T) of the tube, and the mass (M) of the emission centres: $D/\lambda = A\sqrt{(M/T)}$. The value of the constant A is generally deduced from approximate and not altogether satisfactory theoretical considerations, though an exact solution is not difficult. The object of the present paper is to effect this improvement in the theory. Rayleigh took account of the first two interfering beams only, apparently having the Michelson interferometer in mind. In the present paper account is taken of the infinite number of interfering beams, and the effect of reflection. The constant A is then given by the expression $(c/\pi)\sqrt{[\omega/2K \log (2f/V)]}$, where ω = weight of the hydrogen atom, K = universal gas-constant, V = visibility factor, f = fractional reduction of intensity by reflection. According to Maxwell's distribution law, the number of particles with velocities between V and $V + dV$ is $A\epsilon^{-\beta V^2}dV$. The frequency of radiation emitted by these particles is $n[1 + (v/c)]$, where n is the wave frequency of light emitted by the particles at rest. The exact evaluation of the constant A cannot be accomplished unless the reflecting power of the plates and the value of V be known. f depends on the silvering of the plates, while V will vary with the observer. Rayleigh takes $V = 0{\cdot}025$, while Schönrock takes it to be $0{\cdot}05$. Assuming $V = 0{\cdot}025$ and $f = 0{\cdot}75$, the value of A becomes $1{\cdot}50 \times 10^6$. Rayleigh obtained the value $1{\cdot}42 \times 10^6$. A. W.

262. *Interferometry of Small Angles.* **C. Barus.** (Nat. Acad. Sci., Proc. 3. pp. 665–672, Nov., 1917.)—A theoretical consideration of the possibility of using the methods of interferometry previously described [see Abs. 916, 922 (1917)] for the purpose of small angle measurement and the determination of the distance of the source of light. Two such applications are described.

J. W. T. W.

263. *Correction Terms for Concave Grating with Large Ruled Spacing.* **H. Nagaoka.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 208–212, Nov., 1917.)—Continuing from a former paper [Abs. 1337 (1916)], it is shown that the deviation of position of a spectrum line when the diffracting surface is made greater becomes of sufficient magnitude materially to affect the definition.

Curves are given showing the deviation produced for grating widths up to 26 cm., and as example, the recent results on the green mercury line with a 10-in. Michelson grating are quoted as showing the integration effect of principal line and satellites. The revolving power of a concave grating is thus less than that of a plane grating with equal ruled spacing. C. P. B.

264. *Study of the Envelope of Spherical Rays emitted by a Moving Body.* **M. Aubert.** (J. de Physique, 5. pp. 248–264, July–Aug.–Sept., 1916.)—Mathematical treatment unsuitable for abstracting.

265. *Spectrum of Neon.* **K. W. Meissner.** (Archives des Sciences, 44. p. 475, Dec., 1917. Paper read before the Soc. Suisse de Physique.)—From interferometer measurements the author has previously shown that regularities occur in the spectrum of neon [Abs. 224 (1917)], the triplets and quadruplets showing constant wave-length differences. As all the elements of these systems had not been measured by means of an interferometer, it was not possible to complete the examination of the constancy of the wave-length differences, but interferometer measurements now in progress will permit of this being done. The first element of the quadruplets, which had been previously evaluated at 8082·453 Å.U. has been remeasured and fixed at 8082·450. There are about 20 lines in the interval 7900–9000 Å.U., and the exact determination of their wave-lengths is making good progress. Apart from the systems of triplets and quadruplets, the author's calculations show that series also exist in the neon spectrum. Details will be published later.
A. W.

266. *Absorption of Hard X-rays in Gases.* I–IV. **M. Lang.** (Ann. der Physik, 53. 12. pp. 279–319, Dec. 14, and 53. 13. pp. 337–372, Dec. 28, 1917. Dissertation, Frankfort.)—The five sections of the paper deal with the subject as follows:—I. Historical—review of the researches of other physicists. II. Technical details of the investigation—the X-ray tube, the gas-absorption apparatus, measuring apparatus, methods of carrying out the measurements. III. Experiments on the absorption-properties of gases—examination of the effects of varying (*a*) gas pressure, (*b*) hardness of X-rays, (*c*) thickness of "filter" (between bulb and absorption chamber). Comparison of absorption coefficients of air for X-rays and γ-rays. IV. Observations on the dissymmetry in the distribution of the radiation from modern X-ray tubes with Pt antikathodes. V. The relation of "hardness" to "primary load"—variations of secondary current with primary current, etc.

The results of the above investigations are summarised as follows:—

(1) The "standard" method is the only satisfactory method of observation in absorption measurements of X-rays, on account of the inconstancy in behaviour of the X-ray tube. (2) The absorption of a gaseous mixture is in accordance with Benoist's additive law. (3) With regard to gaseous compounds the conception of "mean absorptive-power" has been introduced. (4) For two different gases the quotient $(\mu_1/\rho_1)/(\mu_2/\rho_2)$ always diminishes with increasing hardness of the radiation. (5) For a heavy gas, such as methyl chloride, the absorption at low partial pressures lags behind the pressure. (6) If the gas pressure is doubled the absorption coefficient is *less* than twice its initial value. (7) The value of the absorption coefficient for light media, such as a gas, depends very markedly on the filtering the radiation has undergone previous to entering the gas (*Filterwirkung*). The notion of "average or apparent absorption coefficient" is employed in this connection

V.2
191

and is defined mathematically. (8) With increased *Filterwirkung* the values of the relative absorption coefficients converge. (9) The absorptive-power of a gas is only in a slight degree dependent on the discharge-voltage. (10) In stating the values of absorption coefficients, the "X-ray hardness" and the *Filterwirkung* should also be specified. (11) The "half-value" thickness of air for γ-rays from RaC was found to be only 4 or 5 times greater than for the hard X-rays emitted from the Maximum tube and filtering through 9 mm. of Al. (12) The "standard" method is also suitable for observations on the distribution of radiation. (13) The *Bremsstrahlung* was almost completely separated from the *Eigenstrahlung* after passing through 1 mm. of Al. (14) The distribution of the radiation is dependent on the primary load. (15) The "hardness" of the radiation also depends, to a marked degree, on the primary load. (16) Every X-ray tube has a "Normal Load" at which its behaviour is approximately constant. (17) A design is proposed for an X-ray "Qualimeter," with which "iontometric" determinations of hardness can readily be made. (18) The various possible modes of origin of the hard heterogeneous X-rays from an ordinary tube are considered. (19) The probable existence of K-, L-, and M-characteristic radiations for radio-active substances is demonstrated. (20) The probable strength of field for radio-active atoms has been determined. A. B. W.

267. *K-Series of the Röntgen-ray Spectrum of Gallium.* **H. S. Uhler** and **C. D. Cooksey.** (Phys. Rev. 10. pp. 645–652, Dec., 1917.)—The glancing angles, with respect to calcite, of the K-lines of gallium have been accurately determined. A new method of measuring glancing angles was devised, and found to be superior to the old method. The new method consisted in taking two exposures (right and left) with the plate near the crystal, and two more with the plate remote from the grating, the slits having equal widths. An accurate steel parallel with a suitable back-stop left no doubt concerning how far the plate had been translated along the collimating axis. By taking a short exposure for the lower half of the central image before putting the crystal tripod in place—the plate-holder being in one extreme position—and by making a like exposure for the upper half of the direct image after the characteristic radiations had been impressed and the crystal table removed—the plate-holder now occupying the other extreme position—a criterion for the adjustment of the plate-holder guides was obtained at once. A comparison of the distance apart of the two images of a given spectral line on the left with the homologous distance on the right indicated whether the plane of the plate-holder was normal to the direction of translation. The small errors in adjustment and construction of the apparatus were subjected to computation and found to be negligible, since the corrections never exceeded 0·2″. Assuming the grating space of rock-salt to be $2{\cdot}814 \times 10^{-8}$ cm., calculations based on the experimental results obtained give for the grating space of calcite the value $3{\cdot}0307 \times 10^{-8}$ cm. The weighted mean values for the glancing angles of gallium are as follows:—

$$\text{Calcite}\begin{cases}\gamma_{\alpha_2} = 12^\circ\,47'\,15'' \pm 2''\\ \gamma_{\alpha_1} = 12^\circ\,45'\,\ \,5'' \pm 2''\\ \gamma_{\beta_1} = 11^\circ\,23'\,30'' \pm 2''\end{cases}\qquad \text{Rock-salt}\begin{cases}\gamma_{\alpha_2} = 13^\circ\,47'\,28''\\ \gamma_{\alpha_1} = 13^\circ\,45'\,\ \,4''\\ \gamma_{\beta_1} = 12^\circ\,22'\,32''\end{cases}$$

By applying the method of least squares to the calculation of the parameters of Moseley's linear law and interpolating for gallium (N = 31) the wave-lengths of the α_2, α_1, and β_1 lines are found to be 1·34 Å., 1·337 Å., and

1·191 Å. respectively. The experiments yield the values 1·34161 ± 0·00004, 1·33785 ± 0·00004, and 1·20591 ± 0·00006; so it is clear that gallium falls in line perfectly with the other chemical elements and the laws discovered by Moseley. The agreement between the calculated and experimental wave-lengths is very good, since the data used in the computations show mutual inconsistencies amounting in some cases to nearly 4′. A. W.

268. *Spectrography of Röntgen Rays.* **de Broglie.** (J. de Physique, 5. pp. 227-236, July-Aug.-Sept., 1916.)—Describes a study of the secondary Röntgen rays from a large number of substances, the radiations from which were analysed by means of a crystal which could be rotated as desired. The results are tabulated and compared with those of Siegbahn and Malmer.
A. W.

269. *X-ray Spectra.* **J. Brentano.** (Archives des Sciences, 44. pp. 469-470, Dec., 1917. Paper read before the Soc. Suisse de Physique.)—The work of Beatty [Abs. 606 (1913)] points to the conclusion that the antikathodic characteristic radiation is produced, to a large extent, directly by the kathode-rays and not by fluorescence. Later research, however, indicates that the effect is solely one of fluorescence. The later researches can always be reconciled with the earlier ones by the use of particular hypotheses regarding the mode of emission; *e.g.* the work of Webster [Abs. 1046 (1916)] on "selective absorption" of X-rays, is an illustration of this.

The author favours the view that the characteristic X-radiation is produced directly by the kathode rays. A. B. W.

270. *X-ray Absorption Phenomena.* **M. de Broglie.** (J. de Physique, 5. pp. 161-168, May-June, 1916.)—A spectrum of the rays emitted by an X-ray bulb is obtained in the manner previously described [Abs. 1337 (1914)]. Thin screens of different substances are placed in the path of the reflected beam, and the spectra obtained show the existence of absorption bands which are characteristic of the substances interposed. These absorption bands have very sharp edges on the longer wave-length side, but they gradually fall off in intensity as we proceed to the shorter wave-lengths. The sharp edges of the K-absorption bands of different elements appear at the angles given in the following table, from which the corresponding wave-length may be obtained from the relation $\lambda = 5{\cdot}63 \times 10^{-8} \times \sin \alpha$, the rays being reflected from the (100) face of a crystal of rock-salt.

Element.	α	Element.	α	Element.	α
Cu	14° 15′	Ag	4° 53′	Ce	3° 02′
Se	10° 00′	Cd	4° 40′	Pt	1° 31·5′
Br	9° 20·5′	Sn	4° 16′	Au	1° 29·5′
Rb	8° 16′	Sb	4° 03·5′	Hg	1° 27·5′
Sr	7° 48′	I	3° 44′	Tl	1° 25′
Zr	6° 57′	Te	3° 54′	Pb	1° 22·5′
Nb	6° 35′	Cs	3° 26·5′	Bi	1° 20′
Mo	6° 14′	Ba	3° 18·5′	Th	about 1°
Pd	5° 07·5′	La	3° 09·5′	—	—

As many as three bands are observed in the L-radiation of some of the elements examined. The long wave-length edge of each of these bands is given in the following table; the corresponding wave-length may be calculated by means of the relation between λ and α given above:—

Element.	Band.	α	Element.	Band.	α
Ur	1	7° 20′	Pb	2	8° 17′
	2	6° 00		3	
	3	about 5° 45′	Tl	1	9° 58′
Th	1	7° 44′		2	8° 35′
	2	6° 22′		3	
	3	about 6° 10′	Hg	1	10° 18′
Bi	1	9° 25′	Au	1	10° 37·5′
	2	8° 31·5′		2	9° 11′
	3	about 7° 41′		3	about 8° 46′
Pb	1	9° 40′	Pt	1	10° 55·5′
	—	—	W	1	12° 26′

E. A. O.

271. *Spectra of Isotopes and the Vibration of Electrons in the Atom.* **W. D. Harkins** and **L. Aronberg**. (Nat. Acad. Sci., Proc. 3. pp. 710–715, Dec., 1917.)—According to most of the recent theories of atomic structure and of the origin of light, the emission of light is due to the vibration of the non-nuclear electrons in the atom, but there is a difference of opinion in regard to the process by means of which the radiation takes place. The investigation now described was undertaken with a view to determining if the electronic periods are wholly dependent upon the *net* positive charge on the nucleus of the atom. If such is the case, then it is evident that both the effect (1) of the mass of the nucleus, and (2) of the bound positive and negative electrons, must be extremely small.

The authors consequently have examined the possibility of either of these effects being large enough to produce a measurable deviation on the spectra of isotopes. It might be expected, even if there is no effect due to mass, that if the positive and negative electrons on the nucleus are not considered, their space arrangement should cause a slight, though possibly unmeasurable effect upon the spectrum. The isotopes examined were ordinary lead and lead from radium (RaG). A 6-in. Rowland grating was first used, then a quartz spectrograph of about 25 Å.U. per mm. Both showed no measurable differences. With a 10-in. Michelson plane grating a difference of about 0·0043 Å.U. was found at $\lambda = 4058$, the RaG having the longer wave-length. This value is much more nearly in agreement with Bohr's theory (intended for simple atoms only) than with that of J. W. Nicholson. One remarkable feature of the photographs is that the lines seem to be shifted, and not to be broadened.

A. B. W.

272. *Critical Absorption of some Chemical Elements for High-frequency X-rays.* **F. C. Blake** and **W. Duane**. (Phys. Rev. 10. pp. 697–704, Dec., 1917.)—It has long been known that marked increases in the absorption of X-rays by a chemical element take place at frequencies close to the frequencies of the characteristic X-rays of that element. The coefficient of absorption of the element is much greater on the high-frequency side of the characteristic X-radiation than on the low-frequency side. In the K-series of characteristic rays of an element the α-lines are much stronger than the β and γ lines, but the frequencies of the β and γ lines lie above those of the α-lines.

If the square roots of the frequencies of the characteristic lines in the K-series of different elements are plotted against the atomic numbers of the elements, the points lie on curves which in certain regions approximate to straight lines. These become markedly curved, however, in the neighbourhood of the K-radiation of bromine. The plots published by Moseley in his classical paper on this subject indicate this curvature very clearly. It appeared from the work of the authors [see Abs. 291 (1918)] on the value of "*h*" that the absorption of X-rays by the crystal itself, if not corrected for, would produce a curvature of these plots in the observed direction and of about the observed order of magnitude. Partly on this account, and partly on account of the great importance of measuring the highest frequencies known to be characteristic of the elements as accurately as possible, the authors undertook the present investigation. Results of measurements of the characteristic absorption frequencies of the elements from bromine to cerium are given in the following table:—

Element.	Atomic Number.	θ	λ (Wagner) Å.U.	λ (de Broglie) Å.U.	λ Observed. Å.U.	λ Calculated. Å.U.
Cerium	58	2°54′30″	—	0·2979	0·3073	0·3070
Lanthanum	57	3 1 5	—	—	0·3188	0·3186
Barium	56	3 7 50	—	0·3249	0·3307	0·3308
Cæsium	55	3 15 35	—	—	0·3444	0·3438
Xenon	54	—	—	—	—	0·3575
Iodine	53	3 31 40	—	0·3666	0·3727	0·3721
Tellurium............	52	3 41 20	—	0·3829	0·3896	0·3876
Antimony............	51	3 50 55	—	0·3985	0·4065	0·4041
Tin	50	4 1 0	0·425	0·4183	0·4242	0·4217
Indium	49	4 11 55	—	—	0·4434	0·4404
Cadmium	48	4 23 10	0·468	0·4580	0·4632	0·4604
Silver	47	4 35 35	0·490	0·4793	0·4850	0·4819
Palladium	46	4 48 25	0·513	0·5029	0·5075	0·5048
Rhodium	45	5 2 40	—	—	0·5324	0 5294
Ruthenium	44	5 17 25	—	—	0·5584	0·5559
—	43	—	—	—	—	0·5844
Molybdenum	42	5 51 25	—	0·6113	0·6180	0·6151
Columbium (Nb)...	41	6 9 50	—	0·6455	0·6503	0·6484
Zirconium	40	6 30 55	—	0·6813	0·6872	0·6844
Yttrium	39	6 52 50	—	—	0·7255	0·7235
Strontium............	38	7 18 5	—	0·7641	0·7696	0·7660
Rubidium............	37	7 43 40	—	0·8095	0·8143	0·8125
Krypton	36	—	—	—	—	0·8632
Bromine	35	8 43 5	0·926	0·9139	0·9179	0·9139

Using the above values (Col. VI. in Table) and plotting $\sqrt{(\nu)}$ and N an appropriate straight line is obtained. Moseley's original measurements of the α- and β-wave-lengths indicate this, although they show a departure from the linear relation in a certain region. This departure occurs exactly where it is to be expected, if no correction were made for the penetration of the rays into the crystal.

A. B. W.

RADIO-ACTIVITY.

273. *Radium Content of Sea-salt.* **C. W. Hewlett.** (Terrest. Magn. 22. pp. 178–181, Dec., 1917.)—An account of an investigation of the amount of radium in some samples of sea-salt collected by the *Carnegie* in the Atlantic and Pacific Oceans 1915–1917. The method of investigation was that first used by Joly [Abs. 1414 (1911)], in which the sea-salt is fused with

V.2
191

a mixture of sodium and potassium carbonates and heated to 1000° C., the emanation being presumably carried off with the CO_2 evolved.

In none of the numerous samples tested was any RaEm detected. A. B. W.

274. *A Complete Year's Observations of Penetrating Radiation on the Obir (2044 m.).* **V. F. Hess** and **M. Kofler.** (Akad. Wiss. Wien, Ber. Oct., 1917. Phys. Zeits. 18. pp. 585–595, Dec. 15, 1917.)—Continuous measurements of "penetrating" radiation were made on the Obir, height 2044 m., from Oct. 1913 till Nov. 1914, partly with one, and partly with two Wulf's apparatus simultaneously. Each measurement referred to an interval of time varying from 8 to 10 hours. A definite seasonal variation is shown, with a minimum in March–April, and a maximum in July–Aug. The amplitude of the seasonal variation of the day-observations is about twice as great as that of the night-observations and is considerably less than Gockel's observations gave at normal altitudes. The radiation is independent of temperature; it shows no regular diurnal variation in winter, but in summer there is a slight maximum at 16h. The mean values for day and night are equal. Precipitation, especially thunder-rain, is accompanied by a distinct increase of the radiation.

The variations of the radiation are both absolutely and relatively smaller than at sea-level. This appears to show that the portion of penetrating radiation contributed from outside the atmosphere is nearly constant in intensity. This radiation is apparently not due to the sun, as values for day and night are the same. It is probably due to radium and thorium emanations. R. C.

275. *Radio-activity of Archæan Rocks from Mysore.* **W. F. Smeeth** and **H. E. Watson.** (Phil. Mag. 35. pp. 206–214, Feb., 1918.)—The paper describes an examination of a number of samples of hornblendic schists of the Kolar Gold Field, as well as a number of representative samples from the various components of the Archæan Complex of Mysore, India, in order to determine how far the various formations or groups might be distinguishable from one another by their radio-activity.

These very ancient rocks, all of which are considered to be of igneous origin, were found to contain remarkably little radium. Amongst the various groups which have been differentiated on geological grounds, there are some striking differences in the radium contents of some of them. In the case of a fairly uniform group of rocks (viz. the hornblendic schists of the Kolar Gold Field) the Ra-content does not appear to vary with the depth from the surface. Different igneous magmas appear to contain very different amounts of radium, and the latter, or the minerals which carry it, is subject to magmatic segregation. The amount of radium in the segregated portions of a magma sometimes increases and sometimes decreases with increase of basicity. Amongst magmas, the more basic appear to be lower in radium than the more acid, and, in the products of granitic magmas, the pegmatites appear to carry more radium than the corresponding granites.

In the case of rocks of somewhat similar character and composition, and in which other means of distinction or identification are lacking, a marked difference of radio-activity may afford a means of correlating them with known groups or formations for which the radium limits have been sufficiently determined. A table is given showing the results of measurements on 50 different rocks. The Ra-content of these rocks varies from 0·06 to 6·90 gm. of Ra per 10^{12} gm. of rock. A. B. W.

HEAT.

276. *Thermal Expansion of Tungsten at Incandescent Temperatures.* **A. G. Worthing.** (Phys. Rev. 10. pp. 638–641, Dec., 1917.)—In a paper by Langmuir [Abs. 578 (1916)] on the characteristics of tungsten filaments as functions of temperature, there was given an equation representing the thermal expansion of tungsten. This was quite at variance with the author's expectations—hence the present investigation. For the measurements at high temperatures, hairpin and rectangular-shaped filaments of considerable length, with fine marks scratched on them, were mounted in long, tubular glass bulbs which could be evacuated. The movement of the scratch on the filament was observed directly by means of a travelling microscope—certain precautions being taken. The experimental results are well represented by the empirical relation

$$(L - L_0)/L_0 = 4{\cdot}44 \times 10^{-6}(T - 300) + 4{\cdot}5 \times 10^{-11}(T - 300)^2 \\ + 2{\cdot}20 \times 10^{-13}(T - 300)^3,$$

where L_0 and L respectively refer to the filament lengths at 300° K. and at the temperature T expressed in deg. K. The expansion coefficients at 300° K., 1300° K. and 2300° K. are respectively $4{\cdot}44 \times 10^{-6}$, $5{\cdot}19 \times 10^{-6}$, $7{\cdot}26 \times 10^{-6}$.

A. B. W.

277. *Specific Heat of Liquid Ammonia.* **N. S. Osborne** and **M. S. Van Dusen.** (Am. Chem. Soc., J. 40. pp. 1–13, Jan., 1918.)—The authors have determined the specific heat of saturated liquid ammonia throughout the temperature interval —45° to + 45°, using a calorimeter of the aneroid type. Two distinct and independent methods were used, each of which avoids sources of error present in the other. In the first method the heat added to a fixed amount confined in the calorimeter under saturation conditions and the resulting change in temperature are measured. By using data for the specific volumes of the two phases and the latent heat of vaporisation, the corrections for the vapour are applied, giving the specific heat of the liquid kept saturated. In the second method the calorimeter is kept full of liquid at constant pressure. The heat added to the variable amount in the calorimeter and the resulting change in temperature are measured. A correction for the heat withdrawn in the expelled liquid is determined by special experiments. By use of the data for the latent heat of pressure variation of the liquid, obtained from separate measurements, made with the same apparatus and material, the corrections for pressure variation are applied, the result being to give a second determination of the specific heat of the saturated liquid. The greatest difference between the mean results of both methods and the results of either method as represented by empirical equations is less than 1 part in 1000. As a final result the specific heat σ, in joules per gm. per 1 deg. C., of liquid ammonia, kept saturated, at the temperature θ, for the range of temperature — 45° to + 45° is given by the equation :

$$\sigma = 3{\cdot}1365 - 0{\cdot}00057\theta + 16{\cdot}842/\sqrt{(133 - \theta)}.$$

A. F.

278. *Latent Heat of Vaporisation of Ammonia.* **N. S. Osborne** and **M. S. Van Dusen.** (Am. Chem. Soc., J. 40. pp. 14–25, Jan., 1918.)—The latent heat of vaporisation of ammonia, using a calorimeter of the aneroid type, has been determined throughout the temperature interval — 42° to + 52°.

Ammonia is the only liquid in the calorimeter. Heat, developed and measured electrically in a coil, is transmitted by conduction and convection to the surrounding ammonia, and is utilised to effect the evaporation of a determined amount of the ammonia which is withdrawn as superheated vapour at a determined temperature and pressure. Heat from other sources is minimised by reducing, as far as practicable, the avenues for heat-transfer between the calorimeter and its environment, and by working so as to keep the temperatures of the calorimeter and jacket surfaces nearly equal, means being provided for determining the amount of thermal leakage which is not thus annulled. Initial and final temperatures are measured by a Pt-resistance thermometer. An analysis of the process occurring in the calorimeter during an experiment, leads to a method of calculation of the results whereby data from other sources than the direct calorimeter observations enter only in the computation of correction terms which can, by careful manipulation, be made small. Variations in manipulation were introduced as a means of detecting possible systematic errors, particularly in regard to the matter of dryness of the vapour withdrawn. The result of each of the 34 determinations agrees with the mean result as expressed by means of an empirical equation within 1 part in 1000. An empirical equation was found which, in addition to representing closely the results in the range of temperature covered experimentally, also conforms to what is known about the behaviour of substances in general when approaching the critical point. As a final result, the latent heat of vaporisation of ammonia, that is, the heat in joules per gm. required to convert saturated liquid into saturated vapour at constant temperature, is expressed in the temperature range of —42° to + 52°, by the equation: $L = 137{\cdot}91\sqrt{(133 - \theta)} - 2{\cdot}466(133 - \theta)$. If the latent heat of vaporisation is expressed in cals. (at 20°) per gm. taking 1 cal. (at 20°) = 4·183 joules, the equation becomes $L = 32{\cdot}968\sqrt{(133 - \theta)} - 0{\cdot}5895(133 - \theta)$. [See also preceding Abs.] A. F.

279. *Solubility of Sodium Sulphate as a Means of determining Temperatures.* **T. W. Richards** and **V. Yngve.** (Am. Chem. Soc., J. 40. pp. 164–174, Jan., 1918.)—A salt may serve as a means of fixing temperatures with precision through the determination of its solubility at any point in question, provided that the following conditions are satisfied: (1) The solubility varies considerably with the temperature, (2) the salt is easily obtained pure, (3) the saturation-point is attained quickly from either side, and (4) the solubility is easily determined with accuracy. Sodium sulphate decahydrate, between the temperatures 15° and 25°, satisfies these conditions, as is shown by the authors, and the following solubilities have been determined: t° represents the temperature on the Paris hydrogen scale, and s the number of gm. of Na_2SO_4 in 100 gm. of water:

t°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°
s	13·181	14·185	15·268	16·437	17·698	19·064	20·549	22·155	23·888	25·762	27·795

The temperatures were measured to three significant places of decimals. The solubilities are well represented by the equation $\log s = 0{\cdot}659970 + 0{\cdot}02963889t + 0{\cdot}0000688925t^2$. The above figures are calculated from this equation, the actual determinations being made at about 15°, 17·5°, 20°, and 25°, referred to the Paris hydrogen scale through two standard Baudin thermometers. The Baudin scale as given by these two thermometers does not exactly correspond with the platinum scale in this region, and the divergence cannot yet be explained. [See also Abs. 313 (1918).] T. S. P.

280. *Temperature Determinations by Eutectic Alloys.* **C. P. Steinmetz.** (Am. Chem. Soc., J. 40. pp. 96–100, Jan., 1918.)—Experiments, made in the usual manner by the determination of the cooling curves, have been carried out to see whether and how far the melting-point of eutectic alloys is affected by impurities. The deviation of an alloy from a eutectic may be due to : (1) a deficiency of one or more of the constituents, (2) an excess of one or more of the constituents, and (3) the presence of some metal which is not a constituent of the eutectic alloy. All three cases have been investigated, using various alloys. It is found that in the use of eutectic alloys for temperature determinations, material impurities, caused by metals which are not a constituent of the alloy, may be harmful and are to be guarded against ; but a considerable deviation from the proportions of the normal constituents of the alloy appears harmless. Even the harmful effect of a foreign metal impurity is limited probably to the cases where the addition of such metals forms a eutectic alloy of lower melting-point. The following twelve alloys were found in the range below 200°, which are eutectics or sufficiently near to eutectics in their composition to permit their use ; their melting-points were determined by observing the cooling curves, while stirring with the thermometer :—

Melting-point.	Composition.						Temperature of Undercooling.
	Bi	Cd	Pb	Sn	Tl	Zn	
69·5°	15	3	8	4	—	—	64°
90·0	7	1	6	—	—	—	83
93·5	2	—	1	1	—	—	91
102·4	11	4	—	5	—	—	96
132·0	11	—	9	—	—	—	127
132·5	2	—	—	1	—	—	—
143·5	2	1	—	—	—	—	137
144·8	—	2	5	8	—	—	137
166·5	—	—	—	4	3	—	—
172·0	—	1	—	2	—	—	—
178·3	—	—	3	5	—	—	175
194·0	—	—	—	10	—	1	—

T. S. P.

281. *Heat Convection in Air, and Newton's Law of Cooling.* **W. P. White.** (Phys. Rev. 10. pp. 743–755, Dec., 1917.)—An investigation to obtain data for use in the design of calorimeters. Leakage due to conduction and radiation conform substantially to Newton's law. Heat-transfer by convection, being due to air currents, whose temperature and velocity are both affected by the thermal head is more nearly proportional to the square of the temperature difference. The observed variations from Newton's law are for the greater part to be ascribed to convection. Observation, with the aid of smoke, shows that in narrow layers of air between vertical surfaces at different temperatures, the convection currents flow up one side and down the other with stream-line motion. These currents transport heat to or from the surfaces, only when they turn and flow horizontally. If stream-line motion be assumed, the following can be deduced : (1) The total effect of convection is independent of the height of the vertical surfaces, *i.e.* the convection effect per unit area will vary inversely as the height. (2) The speed of the currents

will vary as the temperature differences between the surfaces. (3) The velocity of the currents and the convection effect will vary as the third power of the distance between the surfaces. (4) The convection will diminish with the mean temperature on account of the increase in viscosity and rarity of the air. (5) The convection currents themselves tend to destroy the temperature difference which causes them. Thus for finite surfaces the currents will not increase with distance as fast as (1), (2), and (3) would indicate. To test these points an apparatus was constructed in which the heat flowed from a rectangular copper box, tight-soldered and placed in an electrically heated bath of kerosene or water. A pair of flat, silvered copper plates, placed back to back, were suspended by silk threads in the copper box and served as receivers. Temperature differences of the walls and receiver were observed by thermo-couples, and similarly the rise of temperature of the receiving plates. Air-gap thicknesses of 8, 12, and 24 mm. were used. So long as stream-line flow obtains the experimental results accord with the deductions above, but at a distance of 12 mm. and a temperature head of 20 deg. C. turbulence enters and the relations change. It is not possible to express the flow simply under these conditions. Tests were also made of the heat-transfer by convection in horizontal layers, the same receiving plates being supported horizontally. The heat-transfer by convection is more than double that when the plates are vertical. L. L.

282. *Vapour Pressure of Liquid Ammonia up to the Critical Temperature. II.* **F. G. Keyes** and **R. B. Brownlee.** (Am. Chem. Soc., J. 40. pp. 25–45, Jan., 1918.)—The authors have measured the vapour pressures of ammonia from 0° to the critical temperature by means of the absolute piston gauge. The normal boiling-point has also been measured, using both the manometric and dynamic methods. The latter method is believed to give the most accurate value for the normal boiling temperature (—33·20° ± 0·05°). The equation for the vapour pressure of ammonia from the freezing-point (—77°) to the critical temperature (132·9°) is

$$\log_{10} p = -1969{\cdot}65/T + 16{\cdot}19785 - 0{\cdot}0423858T + 5{\cdot}4131 \times 10^{-5}T^2 - 3{\cdot}2715 \times 10^{-8}T^3,$$

where the pressure units are mm. of mercury under normal conditions. The pressures given by this equation represent the experimental data within the limits of experimental error, but they are of the order of 1 % higher than the values decided upon by Regnault. An improved method of determining electrically the weight necessary to equilibrate the force due to the mercury column used in the absolute piston-gauge calibration is described. The electrical contact method decreases the time needed to make observations with the piston gauge and also increases the sensitiveness. [See also Abs. 1150 (1917).] A. F.

283. *Limits of Inflammability of Methane-Air Mixtures at different Temperatures and Pressures.* **W. Mason** and **R. V. Wheeler.** (Chem. Soc., J., Trans. 113. pp. 45–57, Jan., 1918.)—In a limit mixture the heat evolved by the combustion of one layer of mixture is just sufficient, in spite of losses of heat by radiation, convection, and conduction, to raise the temperature of the adjacent layer to the ignition-point, so that a flame, once started, is self-propagating. When the initial temperature is raised, the lower inflammability limit of the concentration of the methane should be lowered, and the upper limit be raised; this the authors find in agreement with Taffanel [Abs. 1448

(1913); 281 and 1856 (1914)]; the effect of pressure is not easy to forecast. The authors determine the downward propagation of the flame. They heat the evacuated explosion chamber, introduce the mixture saturated with water vapour (being kept over a mixture of glycerol and water, 1 : 1), and ignite it by a spark after 2 seconds, assuming the gas mixture to have acquired the temperature of the chamber in 2 seconds, [see Burrell and Robertson, Abs. 545B (1915); 434B (1916)]. At initial temperatures of 20, 100, 250, 400, 600, 700, 750, 800°, the inflammability limits were, in per cent. of CH_4, lower limit: 6·0, 5·45, 4·6, 4·0, 3·35, 3·25, —, —, upper: 13·4, 13·5, 14·0, 14·7, 16·4, 18·75, 23·6, 29·0. In the determination of the lower and higher limits the wall temperature is important; at 750° a 3 % mixture ignited without sparking, but a 3·2 % mixture was not ignited by the walls at 700°; hence the ignition temperature of a 3 % mixture would, under the experimental conditions in question, lie between 700° and 750°. The upper limit rose rapidly when a temperature of 600° was exceeded; there is interaction between the methane and oxygen under formation of CO and of H in the interval between introduction of the mixture and the sparking, and further thermal decomposition of CH_4, though slow below 900°; thus a 23·5 % mixture became uninflammable at 750° in 1·5 secs. As regards pressure, reference is made to Terres and Plenz [Abs. 792 (1916)] with whom the authors agree on the whole, while differing from Burrell and Robertson. The authors, experimenting at reduced pressures at 20°, 250°, 500°, find that self-propagation at ordinary temperature became impossible below pressures of 120 mm. of mercury (300 mm. Burrell). As to higher pressures, they find at 760, 1250, 3900, 4650 mm. of mercury lower limits (methane per cent.) of 6·0, 6·05, 6·2, 6·4, and upper limits of 13·0, 13·15, 13·6, 14·05, the lower limits particularly being in close agreement with Terres. Thus the lower and the upper limits are both raised by increased pressure, which is difficult to explain on the kinetic theory. The experiments at low pressures were made in a U-shaped tube of transparent quartz glass: the one limb, 35 cm. high, was closed above; the spark passed in the other limb about half-way down between Pt electrodes. The whole tube was placed inside an electric furnace. The experiments at higher pressures were made in a short, vertical glass tube 13 cm. high, 2 cm. in diameter. H. B.

284. *Adiabatic Invariants of Mechanical Systems.* I. II. III. **J. M. Burgers.** (K. Akad. Amsterdam, Proc. 20. 2. pp. 149–169, 1917. Supplements Nos. 41*c*, 41*d*, 41*e*, to Comm. from the Phys. Lab., Leiden.)—During the past year [see Abs. 49, 52 (1917)], the theory of quanta has made great progress by the study of a class of mechanical systems characterised by the following property: the integral of action, namely, $W = \int 2T . dt$ (where $T =$ kinetic energy), separates into a sum of integrals, each of which depends on one of the coordinates only, viz., $W = \sum_k \int^{q_k} dq_k \sqrt{[F_k(q_k)]}$. In general each coordinate can only move up and down within a certain interval (which is given by roots of the equation $F_k = 0$). From the formula given for W it follows that the momentum corresponding to the coordinate q_k is equal to $p_k = \sqrt{F_k(q_k)}$, hence $\int dq_k \sqrt{F_k} = \int dq_k . p_k$. For this class of systems Epstein and other investigators use the following equation as the principle for the introduction of the quanta: $I_k = \int dq_k . p_k = n_k h$, where during the integration q_k moves up and down once between its limits (n_k being an arbitrary integral number). Ehrenfest having pointed out the great interest for the theory of quanta of the so-called Adiabatic Invariants, *i.e.* quantities the value of which does not change if the system is transformed adiabatically from one state of motion to another, the present author in Paper I attempts to show that the quantities I_k are adiabatic invariants. This is found to be the case, provided no relations of commensurability exist between the mean motions of the angular variables. This supposition was necessary in order that the system might pass consecutively through all the states which are represented by the points of a period cell, so that an integral with respect to the time might be replaced by an integral over the volume of a period-cell.

In Paper II the case is considered where relations of commensurability do exist between the mean motions, and it is shown that if the adiabatic disturbances are limited to such as do not violate these relations, at least certain definite linear combinations of the I_k (with integral coefficients) are invariants. If the system is rigorously periodic, so that the mean motions are all equal, the only combination of this character is found to be the sum of all the phase-integrals (in other words, the integral of action, extended over a full period of the system), the invariancy of which has already been demonstrated by Ehrenfest [see Abs. 408 (1917)]. Epstein, Debye, and Sommerfeld have put these phase-integrals equal to integral multiples of Planck's constant. Schwarzschild, however, has put the quantum formulæ into another and more general form. He supposes that by means of certain transformations it is possible to express the original coordinates and momenta (q,p) as functions of a new system (Q,P), possessing the following properties: (1) The Q are linear functions of the time; (2) the P are constant; (3) the p and q are periodic functions of the Q with a period 2π. These variables Q are the so-called angular variables. He then introduces the quantum formulæ $\int_0^{2\pi} dQ_k . P_k = 2\pi P_k = n_k . h +$ constant. If the character of the system is such that the variables can be separated, it is always possible to introduce angular variables; in that case the formulæ of Schwarzschild and those of Epstein coincide. In Paper III, however, it is shown without making use of the separation of the variables, that provided certain conditions are fulfilled it is always possible to choose the quantities P_k in such a way that they are idiabatic invariants. This is of importance, since the possibility of introducing angular variables is not limited to those systems. The method employed is to take a mechanical system of n degrees of freedom possessing solutions which can be expressed by means of multiple trigonometric series, proceeding by the sines and cosines of n angular variables, between the mean motions of which no relations of commensurability exist, and to show the possibility of determining the canonical momenta corresponding to these angular momenta in such a way that they are adiabatic invariants for an infinitely slow change of the parameters of the system. (The fact that during an adiabatic disturbance the mean motions change and their ratios pass through rational values has to be further inquired into.) H. H. Ho.

285. *Isothermals of Diatomic Substances and their Binary Mixtures.* XIX. *Preliminary Determination of the Critical Point of Hydrogen.* **H. K. Onnes, C. A. Crommelin,** and **P. G. Cath.** (K. Akad. Amsterdam, Proc. 20. 2. pp. 178–184, 1917. Comm. No. 151c from the Phys. Lab., Leiden.)—In Section I of the paper, the apparatus and method are described. The results so far obtained by different observers in the determination of the critical data for hydrogen, show a wide divergence, and all appear to differ very considerably from those which the authors consider to be correct, namely: $T_k = 33{\cdot}2$K., $p_k = 12{\cdot}8$ atmos. The authors have repeatedly been compelled to defer the accurate investigation regarding the critical condition of hydrogen, because they were unable to get over the difficulty of keeping sufficiently constant the temperatures at which the experiments had to be carried out. So soon as the difficulty had been conquered by the construction of a hydrogen-vapour cryostat, a first determination of the critical temperature of neon was made and also a more accurate measurement of the critical data of hydrogen [see Abs. 975 (1917)]. In Section 2, experimental details are given, together with a curve and tables for the vapour-pressures of hydrogen and its critical constants. Section 3 is devoted to description of an estimation of the critical density, and a table is included of the vapour density and liquid density of hydrogen. The critical density is found to be 0·0310, and the critical temperature —239·91° C. H. H. Ho.

286. *The Spectrum of a Rotating Molecule according to the Theory of Quanta.* **J. M. Burgers.** (K. Akad. Amsterdam, Proc. 20. 2. pp. 170–177, 1917.)—Section 1 of this paper deals with Bjerrum's work, who started from the fact that if a molecule which carries a vibrating resonator rotates, this rotation exerts an influence upon the frequency of the light emitted; Bjerrum then explained the structure of the bands which are found in the infra-red absorption spectra of certain gases. It was assumed that the velocity of rotation of the molecule is determined by a condition taken from the theory of quanta, so that ω (the angular velocity) can only have values which are an integral multiple of a certain quantity ω_0. In the spectrum of such a gas a line of the frequency ν_0 will be accompanied by a set of equidistant satellites, given by the general formula $\nu_1 = \nu_0 + n\omega_0/2\pi$. The bands observed in the absorption spectra of water-vapour and other gases actually have a structure that may be described by this formula. On the principles of the theory of quanta, however, we shall be inclined to assume that a given spectral line is not emitted by a vibrating electron, but that it is emitted when the electron passes from a certain definite state of motion discontinuously to another definite state. On the other hand, the electron can absorb light of the same frequency if it passes back from the second state to the first. Now the following question arises: Suppose the electron to move in the field of a rotating molecule; does the rotation of the molecule exert an influence of the same kind on the frequency of the light emitted, as it does in Bjerrum's theory? The object of the present paper is to show that following the lines of theory of quanta, it is possible to deduce, at least for certain rotating systems, spectral formulæ which show the same character as the one given by Bjerrum. Section 2 develops general formulæ for the motion of an electron in the field of a rotating molecule. In Section 3, following the ideas developed by Schwarzschild, the quantum formulæ for the system are introduced. In Section 4 a discussion of the spectrum is given. For simplifying the problem the system has been assumed to rotate about a fixed axis; hence the question arises as to the possibility of giving a more general treatment in which account is taken of the precessional motion of the molecule.

H. H. Ho.

287. *Least Work of Change of Configuration.* **K. Federhofer.** (Phys. Zeits. 18. p. 560, Dec. 1, 1917.)—Discusses this principle and shows that the minimum value of the internal work (L_i) together with its equality to the external work (L_a) may be expressed by the equivalent condition $L_i - 2L_a =$ maximum. E. H. B.

288. *The Constant σ in the Stefan-Boltzmann Law.* **M[arya] Kahanowicz.** (N. Cimento, 13. pp. 142–167, Feb.–March, 1917.)—In the Stefan law, the energy exchanged between two elements of area of black bodies

V.2
191

at absolute temperatures T and T_0 is expressed by the formula $\sigma k\,(T^4 - T_0^4)$, where h is a geometrical coefficient depending on the form of the elements, their dimensions and their distance apart, and σ is the Stefan constant to be determined. A critical *résumé* and discussion follows of the methods of Kurlbaum (bolometer, $\sigma = 5{\cdot}32$ or corrected for reflection, 5·45), Scheiner (Ångström pyrheliometer, 4·73), Féry (conical receiver, 6·3, 6·3), Bauer and Moulin (Ångström pyrheliometer, 5·7), Valentiner (Kurlbaum bolometer, 5·88, 5·58), Féry and Drecq (thermometer, 6·51), Gerlach (Paschen receiver, 5·803, 5·9), Puccianti (bolometer, 5·96, 5·96), Puccianti (thermometer, 6·15), Keene (thermometer, 5·89), and Coblentz (modified Paschen receiver, 5·65, 5·79). A new determination by the author, with a modified Amerio receiver, gives $\sigma = 5{\cdot}60$ or, corrected for reflection, 5·61. A. D.

289. *A Physical Interpretation of Entropy.* **J. Lahousse.** (Rev. Gén. d'Él. 1. pp. 843–845, Dec. 1, 1917.)—The present article is claimed by its author to be both didactic and technical : didactic, because it is shown that the entropy is measurable, at least theoretically, like a quantity of heat ; technical, because the process of reasoning employed constitutes an excellent basis for explaining in a simple manner the theory of heat engines. The author first discusses in detail Carnot's Cycle and his theory of heat engines, and then proceeds to develop a method employed by Gouy in 1889, which latter for a considerable time has been unnoticed. The object was to define a function which should be less abstract than entropy, namely, a function which he terms the available (free) energy and which possesses the advantage of not requiring more data than the method of cycles, being based on the equilibrium conditions of a system. Gouy referred all problems to the single consideration of mechanical work, for which purpose he considered only a single heat reservoir at constant temperature—that of the surrounding medium. To account for reversible exchanges of heat, he supposes these to be effected by small Carnot machines. This available energy function possesses the very important property of diminishing for every spontaneous transformation of the system, and, in order to make a cycle of transformations, it is necessary to perform positive work, *i.e.* the equilibrium of the system with the surrounding medium corresponds to the max. available energy. The author then deals with Gouy's expression of the available energy as a simple function of the internal energy and the entropy. For isothermal transformations carried out at the surrounding temperature the available energy is seen to be identical with the function $\phi = U - JTS + PV$, that is, the thermodynamic potential at constant pressure. In conclusion the author emphasises the advantages which this method possesses from the technical standpoint. H. H. Ho.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

290. *Unipolar Induction and Electron Theory.* **G. B. Pegram.** (Phys. Rev. 10. pp. 591–600, Dec., 1917.)—The most simply constructed apparatus for showing unipolar, homopolar, or acyclic induction of electromotive force is a cylindrical permanent bar magnet spinning about its axis, with a stationary loop of wire terminating in brushes which make contact with the rotating magnet at two points, one nearer the end of the magnet than the other. The old unipolar question is as to the seat of the electromotive force, whether in the moving magnet or in the stationary wire; or, as sometimes put from the standpoint of the "cutting of lines of force" view, does the magnetic field rotate with the magnet and by cutting the stationary loop generate an e.m.f. in it; or does it remain stationary and cut the moving magnet? In terms of the electron theory the question is whether electrons in the conducting material of the magnet, and rotating with the magnet, are acted on by a force arising from this rotation or whether it is the electrons in the stationary loop of wire that are immediately influenced by the spinning of the magnet. Of late certain questions involving the theory of relativity have also been brought into discussions. [See Abs. 1179 (1913) and 115 (1914), also G. Howe, Abs. 242 (1916) and subsequent discussion.]

The experiments described confirm the results of Barnett and of Kennard showing that in unipolar induction the "seat of the electromotive force" is in a moving conductor and is entirely independent of the rotation of the magnetic field.

The facts of unipolar induction are in accord with the theory of relativity. The theory of unipolar induction emphasises the importance of the electron theory and the vector potential function in the discussion of such questions.

E. H. B.

291. "*X-ray*" *Determination of* "*h.*" **F. C. Blake** and **W. Duane.** (Phys. Rev. 10. pp. 624–637, Dec., 1917.)—Duane and Hunt have proved experimentally [Abs. 1419 (1915)] that the voltage V required to produce X-rays of a given frequency ν is determined by the quantum relation: Energy of electron $= \mathrm{V}e = h\nu$. Conversely, the law may be stated: the quantum relation gives the max. frequency of the X-rays produced when we apply a voltage V to an X-ray tube. This law holds for the "general" X-radiation, but is not strictly true for "characteristic" X-radiation [see Webster, Abs. 1046 (1916)].

The present paper describes a research carried out to determine "*h*," using spectrometer measurements of "general" radiation, a special design of ionisation vessel being employed in the usual rotating crystal method.

An interesting correction is made for the penetration of the X-rays into the crystal, this correction being applied to find the "effective" reflecting plane and its distance from the axis of rotation of the crystal. Corrections were also made for the finite width of the slit and for the fact that the ionisation-chamber angle may not be exactly twice the crystal-table angle.

A series of curves and tabulated results are given from which the value of "*h*" is calculated. The average value for "*h*" is $6{\cdot}555 \times 10^{-27}$. This agrees very closely with the value of "*h*" calculated from Bohr's formula $\mathrm{N} = 2\pi^2 e^4 m/h^3$ for Rydberg's constant, namely $h = 6{\cdot}544 \times 10^{-27}$, the value

V.2
191

of N being taken as $8{\cdot}290 \times 10^{15}$ and the value of e/m as $1{\cdot}77 \times 10^7$ e.m. units. Using the above value of h (determined by the authors) to calculate e/m we get $e/m = 1{\cdot}761 \times 10^7$ e.m. units.

A list is given of some of the most recent determinations of h, both by means of X-rays and by the photoelectric effect. A. B. W.

293. *The Radius of the Electron and the Nuclear Structure of Atoms.* **J. W. Nicholson.** (Phys. Soc., Proc. 30. pp. 1–12; Disc., 12–13, Dec., 1917.)—The electron is usually regarded as a globule of electricity with a definite radius. This conception has proved valuable, but involves difficulties in connection with the nuclear structure of complex atoms. On the view that the electron consists of a region of strain in the ether such line constants should have some significance throughout the whole ether; which may, in fact, be in some manner cellular with these linear magnitudes involved in the specification of the cells, and therefore in any strained structure composed of them.

The electron would be regarded as a state of strain which for practical purposes is concentrated at its centre, rapidly diminishing outwards according to some very convergent law involving some line constant in its specification. By way of illustration the idea is worked out mathematically on the assumption that the strain varies as $\epsilon^{-\lambda r}$, on which hypothesis λ^{-1} is the "radius." It can be shown that the Lorentz formula for mass as a function of velocity can be obtained for this type of electron. The charge on the electron is regarded as a fundamental property of the ether, and is related to Planck's constant h.

AUTHOR.

293. *Problems of the Potential Theory.* **A. Bolliger.** (Archiv f. Elektrot. 6. pp. 100–112, and pp. 134–160, 1917.)—The paper opens with a tabulation of the most important analytical formulæ applicable to potential problems, followed by Section 1, which deals with the fundamental electrostatic equations employed for their solution. Lagrange has established that the components of the electric force due to static charges may be derived as partial differentials from a single so-called potential function, and according to the theory of action at a distance the latter may be expressed as a space integral over all the electric quantities within the zone. This potential expression is established in the present paper and the contour conditions are investigated. In Section 2 the case of a disc with a circular hole is considered; the concentric distribution of electricity is determined for any given arbitrary radial function of an axially symmetrical potential. The general results obtained are analogous to the solutions found by Hafen for the circular disc. The expressions for density and potential in the more simple cases may be completely determined by integration. In Section 3 a typical example of the latter is given, namely, the action of an electric pole upon an annular disc, and a diagram is shown of the lines of force along a meridian section. Section 4 deals with the general theory of the linear conductor *in vacuo*. A *résumé* is first given of previous work on the properties of the electromagnetic field of linear conductors *in vacuo*. Neumann's introduction of the idea of electrodynamic potential has shown the possibility of expression by a simple integration method of the induced effect consequent on linear currents. The author remarks that he cannot find in the existing literature a complete expression for the element from which the total electromagnetic state can be evolved. He next deals with the equations proposed by previous authors, and completes them in the latter respect while extending the general theory of linear conductors. Maxwell's field and supplementary equations, as also the use of vector analysis, constitute the starting-point. The results obtained show that the formulation of the elementary laws governing the magnetic and electric field may be advantageously performed by the introduction of the so-called vector potential. By this means the components of the force may be completely derived as partial differential coefficients. The investigation on linear conductors has to be supplemented by a study of how far the influence of the charge on the conductor (apparently static) is to be traced to the current flow. Owing to the rapid propagation of electricity and the continuity of the current, the electronic density in a conductor of constant cross-section must be uniform throughout. A discussion of this problem concludes the chapter. In Section 5 the potential of a free conductor is considered, while Section 6 deals with the problem of insulators. The latter is treated from the standpoint of an annular disc having a straight, linear conductor at its axis. The cases for unlimited and finite lengths of the linear conductor are considered. Section 7 investigates the axial distribution of an infinitely long cylinder of circular cross-section. In Section 8 the potential within a hollow cylinder is obtained. An appendix deals with the construction of the lines-of-force diagram, and also contains a supplementary note on the influence of an electric pole on the annular disc. Numerous diagrams illustrate the paper, which is mathematical throughout. H. H. Ho.

294. *Ions produced by Spraying of Water.* **J. J. Nolan.** (Roy. Soc., Proc. 94. pp. 112–136, Jan. 1, 1918.)—In previous papers [Abs. 1702 (1914), 804 (1916)] the nature of the ionisation in water-spraying has been explained. In the first part of the present paper a departure from the methods previously employed is described, the aim being to separate out more effectively the ions as produced, and so to arrange that the ions could be examined very soon after production, and thus reduce loss in ions by recombination and diffusion. To attain these ends a new form of apparatus is adopted. A fine nozzle is used to spray water just over and parallel with a metal plate at the bottom of a wooden box. A strong current of air is drawn through the box in the direction of the spraying. The plate at the bottom of the box is connected to a potentiometer, so that it may be charged to any desired potential. Near the top of the box, and parallel with the bottom plate, are two other plates connected respectively to earth and to an electrometer. When ions of mobility u are produced by the sprayer, they will traverse a horizontal distance L at voltage V, and arrive at the end of the upper (electrometer-joined) plate. Then Q being the volume of air passing per sec. between the plates, a the distance between the plates, and b the inside width, we have $uV = Qa/Lb$. On plotting current-voltage graphs the author obtains, as expected, graphs formed of curved steps, each step representing the collection of a group of ions of a certain mobility. The above formula enables him to find mobility from the voltage on the graph. The range of mobility observed varies from 1 to 27.

In the second part of the paper the theory as to the size and mass of larger ions and the mobility of the smaller ions produced from water is considered in connection with the formulæ of G. G. Stokes and J. J. Thomson, and it is suggested that it is possible to state the number of molecules included in an ion from its known mobility. P. E. S.

DISCHARGE AND OSCILLATIONS.

295. *Total Ionisation by Slow Electrons.* **J. B. Johnson.** (Phys. Rev. 10. pp. 609–623, Dec., 1917.)—The paper describes a determination by a direct

V.2
191

method of the total ionisation produced by electrons, of velocities up to 200 volts, in nitrogen, hydrogen, oxygen, and helium. It is shown that the total ionisation in these gases is proportional to the energy the electrons possess above the minimum ionisation energy, at least up to 150 volts. The results are practically the same in the four gases, in accord with results at higher velocities. The author gives reasons indicating why the values of the total ionisation measured by Kossel [Abs. 907 (1912)] are too low. A. B. W.

296. *Time Variation of Potassium Photoelectric Cell.* **H. E. Ives.** (Astrophys. J. 46. pp. 241–248, Nov., 1917.)—A previous study of potassium photoelectric cells [Abs. 110 (1915)] showed that the distribution of sensibility through the spectrum varied greatly among cells made in the manner usual at that time, and the present investigation was undertaken in the hope of finding a method of preparing the cells so that they would have the same characteristics of sensibility according to wave-length from cell to cell, and also to determine whether the spectral sensibility curve remained constant with time and use. Measurements through the spectrum were made at first every day, then weekly, and then irregularly at longer intervals. The curves resulting from the data obtained show that the wave-length sensibility suffers a continuous change with time, the cause of which, it is thought, may be the gradual sintering of the highly sensitive surface. It is concluded that the photoelectric cell is not at present suited for *photometric* measurements of luminous flux, but it is efficient for *radiometric* determinations such as stellar radiation, distribution curves of illuminants, densities of photographic plates and spectro-radiometry. For the last purpose attention should be devoted to the problem of producing a flat extended curve of wave-length sensibility in place of the usual one with a sharp maximum. C. P. B.

297. *Measurement of Ionisation in Geissler Tubes.* **E. Rumpf.** (Ann. d. Physik, 53. 18. pp. 373–408, Dec. 28, 1917.)—The paper is divided into three sections: (*a*) a description with diagram of the apparatus employed, (*b*) the results obtained, (*c*) a theoretical discussion of the problems relative to ionisation in Geissler tubes. It is found that the ionisation reaches a maximum in the negative glow, is independent of the pressure, and there is a direct relationship between the ionisation and the strength of the chief current in the tube. There is no essential difference in the behaviour in air or hydrogen.
A. E. G.

298. *Magnetic Phenomena at the Anode.* **G. Gouy.** (J. de Physique, 5. pp. 221–227, July–Aug.–Sept., 1916.)—It has long been known that certain phenomena are exhibited at the kathode of a discharge tube in the presence of a magnetic field. The present paper describes a number of experiments which show that the anode is also the seat of characteristic effects. With a field of about 1000 gauss, a spiral is often seen leaving the anode, and the spiral widens out when the field strength is reduced. As the field strength is increased an unstable stage is reached, beyond which a brilliant corona is obtained surrounding the anode. If the corona encounters an obstacle a zigzag is formed in certain cases. A metallic body connected to the kathode repels the corona without touching it. Several photographs of the different effects are given. In securing these effects it is essential to avoid the presence near the anode of magneto-kathodic rays which may issue from the kathode itself or from secondary kathodes on the walls of the discharge tube. This may be done by lining the tube with metal foil, which may be connected to the kathode, or be well insulated, windows being furnished for observation purposes. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

299. *Specific Resistance and Thermoelectric Power of Calcium.* **C. L. Swisher.** (Phys. Rev. 10. pp. 601–608, Dec., 1917.)—Matthiessen's determinations, in 1857, give the specific electrical resistance of Ca as $7{\cdot}7 \times 10^{-6}$ ohm-cm. at 16·8° C. Later measurements by Moissan and Chavanne [see Abs. 1090 (1905)] give $10{\cdot}5 \times 10^{-6}$ ohm-cm. at 20° C. In the present investigation the resistance has been measured up to a temperature of 600° C., a potentiometer method being employed. The Ca was obtained from Kahlbaum and had a purity of 99·57 %. For resistance measurements it was drawn, under oil, to wires about 15 cm. long and 0·25 cm. in diam. The specimen was placed centrally in a cylindrical iron tube, heated electrically, and the air was withdrawn from the tube by a pump working continuously. At 20° C. the specific resistance is found to be $4{\cdot}6 \times 10^{-6}$ ohm-cm. The resistance increases linearly up to 600° C., the temperature coefficient being 0·00364. For the thermoelectric measurements, annealed Pt-wires were pressed firmly against the ends of Ca rods about 7 cm. long and 1·2 cm. in diam. The temperatures of the Pt and Ca junctions were measured by Pt and Pt-Rh thermo-couples. The Pt-wire of the Pt-Ca couple was checked against a piece of pure test lead. The thermoelectric power was found to be + against lead. The values range from 8·9 microvolts per 1 deg. C. at 50° C. to 14 microvolts at 400° C. L. L.

300. *Electrical and Thermal Properties of Iron Oxide.* **C. C. Bidwell.** (Phys. Rev. 10. pp. 756–766, Dec., 1917.)—In a previous report [Abs. 1152 (1916)] the author has given the results of an investigation on the electrical resistance and thermoelectric power of iron oxide. The composition was described as Fe_3O_4. The thermal treatment to which the specimens were subjected would completely oxidise the material, and those results must therefore be regarded as pertaining to Fe_2O_3. In the present research two methods of preparation of the oxides have been employed. (1) A quantity of Fe_2O_3 was fused in an arc furnace. The resulting solid mass (Fe_3O_4) was ground to powder, compressed hydraulically, and then baked to a bright red heat for about 1 hour. This treatment gave a comparatively stable material of composition Fe_2O_3 which could be ground to rods about 15 mm. long and 6 mm.^{2} section. (2) Specimens of the composition Fe_3O_4 were prepared by moulding the molten oxide to the form desired. They are unstable, heating to about 300° or 400° C. resulting in the formation of a large proportion of Fe_2O_3.

The resistance and thermoelectric power against Pt were measured up to about 1520° C., the melting-point of these oxides. The specimens were heated in a suitably designed electric furnace, an additional heating coil over one end of the specimen being utilised for producing a temperature gradient for the thermoelectric measurements. By this means the resistance and thermoelectric power could be measured as the mean temperature of the specimen was gradually increased to the maximum and then allowed to fall gradually. The results are represented graphically in the paper.

Speaking generally, Fe_2O_3 is characterised by high electrical resistance and large thermoelectric power, whereas the resistance of Fe_3O_4 is small and the thermoelectric power small. For Fe_2O_3 there is a transformation-point at about 710°–780° C. both for resistance and thermoelectric power. The latter is about 600 microvolts for 1 deg. C. at 400° and obeys a linear law up to the transformation-point. After this it increases to a maximum + value

V.2
191

at 1125°, then diminishes to zero, and finally becomes negative. The resistance follows the exponential law suggested by Koenigsberger and shows a second marked transformation point at 1320°.

Definite results with Fe_3O_4 are masked by partial oxidation which occurs on heating. The resistance at room temperature was about 1 or 2 ohms, and dropped to 0·2 ohm at about 1200° C. A transformation-point is indicated at 600° to 800°. On cooling from 1400° C. the resistance increases rapidly. The thermoelectric power is indicated by two straight lines differing slightly in slope, the transition occurring between 700° and 800° C.

The change of thermal conductivity with temperature was also measured in the case of Fe_2O_3. A hollow tube of the compressed oxide was prepared and the conductivity determined from the radial heat-flow through the walls of the tube. Observations were made up to 1050°. The variation with temperature follows a linear law, but a change of slope in the line is indicated at 720° C. L. L.

301. *Thermoelectric Properties of Fused Metals.* **C. R. Darling** and **A. W. Grace.** (Phys. Soc., Proc. 30. pp. 14–20 ; Disc. 20, Dec., 1917.)—In a previous paper [Abs. 249 (1917)] the authors described experiments with bismuth, the apparatus then used only being capable of furnishing readings up to 560° C. Methods have now been devised in which the metals examined may be heated in the tube of an electric furnace, and observations made up to the temperature limit of the furnace. The metals experimented with were Pb, Sn, and Sb up to 1000° C., and Zn and Cd up to temperatures approaching the boiling-point. No change in thermoelectric properties was noticed at fusion, except in the case of antimony, which, like bismuth, shows an abrupt bend in the e.m.f. temperature curve at the melting-point, 632° C. This exceptional behaviour of Sb and Bi is in keeping with the anomalous properties of these metals, both of which expand on solidification ; and it is suggested that an allotropic change occurs at fusion in these metals.

In the case of Pb, which is used as the reference metal in thermoelectric diagrams, it is shown that extrapolation of lines in the diagram beyond 300° led to serious errors, and that although at low temperatures the e.m.f.-temperature curves are approximate parabolas, the departure from this shape above 300° is so marked as to render thermoelectric diagrams of little value. AUTHORS.

ALTERNATING CURRENTS AND MAGNETISM.

302. *Large Laboratory Electromagnet.* **P. Weiss.** (Archives des Sciences, 44. pp. 464–465, Dec., 1917. Paper read before the Soc. Suisse de Physique.)—In the latest type constructed by the Oerlikon Co. the pole-pieces have a diam. of 19·5 cm. and the distance between them can be regulated by a screw. For convenience in certain magneto-optical experiments the pole-pieces are bored. There are two exciting coils of copper tubing, 6·4 mm. external and 3·6 mm. internal diam. Normally these carry a current of 100 amps. and are cooled by water circulating through them. Each of the exciting coils is built in 5 sections of 144 turns, which are connected in series for current and in parallel for water circulation. With 144,000 amp.-turns and a pole distance of 45 mm. a field of 15,000 c.g.s. units is obtained. L. L.

303. *Measurement of Magnetisation as a Function of Temperature and Field.* **A. Piccard.** (Archives des Sciences, 44. p. 466, Dec., 1917. Paper read before the Soc. Suisse de Physique.)—In this method two exactly similar coils are placed coaxially between the poles of an electromagnet and connected in opposition to a ballistic galvanometer, so that variations of flux due to the electromagnet do not affect the galvanometer. The material under investigation is first placed centrally within one coil, then displaced along the common axis into the other, and the throw of the galvanometer noted. A Ni sphere, magnetised to saturation at ordinary temperature, is used to standardise the apparatus. To study the effect of change of temperature on the magnetisation the specimen is wound with a heating coil. Convection effects are avoided by a suitably designed water circulator. L. L.

304. *The Magneton and Solutions of Paramagnetic Salts.* **P. Weiss.** (Rev. Gén. d'Él. 2. pp. 925–936, Dec. 15, 1917.)—An article on the further evidence supporting the magneton theory; the experimental work quoted in the article is from previous papers [see Abs. 518 (1913), 562 (1914), 1569 and 1570 (1915)]. The general scope of the paper is given in the introductory paragraph: the determination of the moment of the magnetic atoms contained in saline solutions is only possible by indirect means, by applying the kinetic theory. The problem is complicated by the presence in a solution of several carriers of magnetism differing amongst themselves in their chemical function. Such are molecules, simple and complex, ions, simple and complex, products of hydrolysis, and hydrates. All these carriers possess, in general, different numbers of magnetons. The result of experiment often gives these numbers as fractions, but when the variation of atomic moment with concentration is studied, whole numbers of magnetons appear for the extremes of concentration, *i.e.* for very strong or very weak solutions. Sometimes the limiting state is reached by means of reagents which cause a retrograde action of ionisation or hydrolysis, or, more generally stated, they displace the state of equilibrium of the different constituents. Analysis of the curves representing magnetic moment in terms of the concentration of the salt itself or the added reagent gives the magneton numbers present as 16, 19, 24, 25, 26, 27, and 29. The study of the paramagnetism of salts, apart from its importance in the theory of the magneton, is also of much interest as a means of investigation of the constitution of solutions. G. E. A.

305. *Energy of Magnetisation of an Iron Crystal.* **K. Beck.** (Archives des Sciences, 44. pp. 465–466, Dec., 1917. Paper read before the Soc. Suisse de Physique.)—The potential of a crystal of iron situate in a magnetic field is expressed by Weiss as the sum of two terms (1) that due to position, (2) the energy of magnetisation. Measurements have shown that the second term is infinite when saturation is reached. Taking the axes of the crystal as coordinate axes the change in the energy of magnetisation in any chosen direction, defined by the angles θ, ϕ, is given by $A\,(\sin^2 2\theta + \sin^4\theta \sin^2 2\phi)$. The mean value of A is found to be 13,000 ergs. L. L.

306. *Magnetic Storm and Aurora, Dec.* 16–17, 1917. **C. Chree.** (Nature, 100. p. 344, Jan. 3, 1918.)—The Kew records show that the activity of the storm was greatest between 16h. and midnight on Dec. 16th. The range of declination was 34′, of H (horizontal force) 400γ and of V (vertical force) 250γ. A very rapid movement in H ended at 21h. 15m., the element falling 215γ in less than 10 mins. A series of oscillations with a mean period of about

V.2
191

22 mins. was shown on the declination trace from 14h. 30m. to 21h. Oscillations roughly in phase with these were shown on the H trace for part of this period. At Eskdalemuir the range of the disturbance was much greater than at Kew. Aurora was observed from many stations in Scotland and Ireland on the same night. J. S. Dr.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

307. *Dosimetry in X-Radiotherapy in the Services of the Army.* **Guilleminot.** (Comptes Rendus, 165. pp. 462–465, Oct. 8, 1917.)—In general, sufficient account of the usefulness of the radiation at different depths is not taken into consideration. The object of the author is to make this useful effect precise and so to make possible a judicious choice of the quality of the rays employed. With any given radiation it is necessary, if the wound is superficial, that the first layers traversed by the rays shall absorb the necessary curative dose, while, on the other hand, if the skin is healthy no more than the max. harmless dose should be absorbed by it, sufficient dose being at the same time distributed to the pathological tissue to set up therapeutic action. The useful action depends only on the fixed doses. A table is given showing some types of radiation suitable for certain depths and the use of this table is fully explained. A. E. G.

308. *A New Fluorometric Apparatus for measuring Doses of Röntgen Rays.* **H. Guilleminot.** (Comptes Rendus, 165. pp. 701–703, Nov. 19, 1917.)—The determination of the quality of Röntgen rays can be easily carried out by means of the Benoist radiochromometer or similar apparatus, but it is much more difficult to ascertain the quantity. One of the principal sources of error is that the radiotherapy of deep-seated lesions requires very penetrating and highly filtered rays and such radiations do not act sufficiently upon chemical reagents to allow precision in dosing. The fluoroscopic method does not present the same difficulty. In the apparatus here described the object is to substitute a cheaper means for the radium standard which was used in older forms. A small circle of unpolished or opaline glass, which is divided into halves, is viewed by means of a monocular or binocular glass. One half of the unpolished glass is lighted from behind by the luminescence of a small screen of barium platinocyanide which is acted upon by the X-rays under observation, the other half is lighted by a standard electric lamp which is run on an absolutely fixed voltage and the light from which is allowed to pass through blue, yellow, or green screens according to the colour of fluorescence obtained on the screen. There is an arrangement for regulating the light from the lamp from within the ratio 1 : 12 about. The two principal inconveniences of such a fluorometric apparatus are: (1) there is a risk of the barium platinocyanide screen becoming brownish under the action of the rays; (2) the luminous standard may alter with usage. These are discussed and a method of meeting the second objection is described. By using an Al filter the apparatus can also be used as a qualitometer. A table is required to ascertain the intensity of the radiation at various distances, while by means of a second table the force of penetration of the radiation, expressed in the fraction transmitted, is indicated as a function of the intensity before and after filtering. [See also preceding Abs.] A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

309. *Determination of the Density of Helium by Means of a Quartz Micro-balance.* **T. S. Taylor.** (Phys. Rev. 10. pp. 653–660, Dec., 1917.)—The present investigation was undertaken for the purpose of determining the density of helium more accurately than had been done previously, by the use of a quartz micro-balance after the type which was first described by Steele and Grant and later used by Gray and Ramsay in their determination of the density of radium emanation. Aston's description [see Abs. 587 (1914)] of a simple form of a more accurate micro-balance is briefly referred to. The author has found that balances similar to the above, having knife-edge and plane supports, fail to have an entirely reliable zero position of equilibrium under similar conditions. In consequence he decided to try a balance of the Nernst type, and found this to be entirely reliable and satisfactory for accurate comparison of the densities of gases. A very full description of the balance is given, together with manipulative details. The helium used had been separated by Boltwood from thorianite obtained from the Galle Province, Ceylon. The preparation and purification of the gases used, namely: helium, hydrogen, and oxygen, are described. The values for the density of the helium with reference to both hydrogen and oxygen were found to be 0·17848 ± 0·000012 and 0·17850 ± 0·000015 respectively. The molecular weight of helium, calculated in terms of oxygen as 32, was found to be 4·0008 ± 0·0005. H. H. Ho.

310. *Some Substitutes for Platinum Ware.* **R. F. Heath.** (Met. and Chem. Eng. 17. pp. 666–667, Dec. 1, 1917.)—The author has investigated the effects of heat on, and the solubility, in various acids (HCl, H_2SO_4, and HNO_3), of crucibles made of the following materials: gold, silver, nickel, fused quartz, and a composition ware made of canadium, 1 part; Pd, 1 part; Pt, 2 parts; Ni, 6 parts. A crucible made of platinum was similarly heated for the sake of comparison. No new results are presented with crucibles made of the first four materials, but the crucible made of composition ware was found to be an excellent substitute for Pt. Such crucibles have been in use for eight months in the author's laboratory, with satisfactory results. The melting-point of the ware is about 1570°; it is not readily attacked by any single acid, but nitric acid attacks it most (a crucible weighing 31·567 gm. lost 0·006 gm. after immersion in nitric acid, sp. gr. 1·42, and 18·5°, for 30 mins.). It is attacked by the halogens, and the same care should be observed with this ware as with Pt. It can be used as anodes and kathodes in electrolyses, and is a perfect substitute for Pt at about one-half the cost. T. S. P.

311. *Molecular Attraction.* XV. *Specific Heats of the Elements and some Energy Changes.* II. **J. E. Mills.** (J. Phys. Chem. 21. pp. 623–648, Nov., 1917.)—In a previous communication [Abs. 1199 (1917)], the author had collected together the most trustworthy data referring to specific heats, heats of fusion, etc., and some of these data are now discussed in the present paper. The total energy added to a monatomic element from 0° absolute to its melting-point, including the heat of fusion, divided by the absolute temperature of the melting-point, is nearly the same as the specific heat of the liquid element at its melting-point. The heat of fusion is therefore supplementary to the

V.2
191

specific heat of the solid, and the specific heat of the liquid monatomic element can be extrapolated to the absolute zero without great error so far as the total energy content of the liquid is concerned. In the case of monatomic elements, the atoms of such elements in the liquid condition at their melting-point T contain an amount of energy *approximately* proportional to the temperature (usually between 7·5 T and 8·5 T cals. per gm. atomic weight). The theories based on the supposition that metallic electrons require notable specific heat energy are wrong. When we consider the total energy added to a substance, it can be accounted for as being used in the following ways: to perform external work, to increase translational motion, to overcome molecular attractive forces, to increase motion within the molecule, and to overcome chemical forces of attraction. The author shows how the energy required for these different purposes (except the last) can be calculated, the results obtained being compared with, and on the whole confirmed by, experimental data. Where divergences are found, the author is inclined to attribute these to the incorrectness of the data. If this view is correct, then the inverse square law of attraction holds true for molecular forces to the absolute zero for both liquid and solid. Between the temperatures of — 20° and 360° C., the reciprocals of the distances apart of the molecules of liquid mercury decrease almost exactly linearly with the temperature. The author points out in conclusion, that the heats of fusion of lead, phosphorus, hydrogen, gallium, and lithium should be re-determined, as well also as certain data for copper, zinc, chlorine, and oxygen. A thorough experimental investigation of the energy changes of the liquids which S. Young has studied so carefully, would prove of far greater benefit than ten times as much work spent in making heat measurements on miscellaneous liquids. A. F.

312. *Liquid Crystals.* II. *Influence of Temperature on the Extinction; further Experiments upon the Influence of the Magnetic Field.* **W. J. H. Moll** and **L. S. Ornstein.** (K. Akad. Amsterdam, Proc. 20. 2. pp. 210–216, 1917.) —The method described in a previous communication [see Abs. 1876 (1917)] was employed in this supplementary research, with a few modifications which are detailed in the paper. The extinction in its dependence on the temperature was measured in the following way: The matter that has been melted before between two glasses and congealed afterwards, is put on the oven the temperature of which is below the melting-point. Then such a value is given to the heating current that eventually the melting to isotropic-liquid will be reached. After the substance has been molten for a short interval, the heating current is suspended (or diminished) whereby the substance gets liquid-crystalline again and congeals afterwards. The extinction is registered during this rising and falling of temperature. The substances examined were *p*-azoxy-anisol, *p*-azoxy-phenetol, anisaldehyde, and *p*-azoxy-benzoic acid ethyl ester. Figures are given showing the curves of extinction, and these on scrutiny show that the extinction in the liquid-crystalline condition, proceeding from melting of the solid phase (ex-solid), is different from the liquid-crystalline condition formed by cooling of the isotropic liquid (ex-liquid). This different extinction is accompanied by an absolutely different aspect. These differences are mostly conspicuous in the case of *p*-azoxy-benzoic acid ethyl ester. With this substance the ex-solid condition is milky-opalescent, the ex-liquid grainy-opalescent, and when the preparation is heated the first condition always changes into the other at the same temperature. With both ex-solid and ex-liquid the temperature

appeared to exercise a plainly perceptible influence on the extinction, but the direction of the effect is, for the photographically active rays just the reverse of that for the ultra-red rays, *i.e.* for the short waves at rising temperature the extinction increases. Since the effect of temperature in the case of strongly differing wave-lengths may have a different sign, the apparent contradiction between Schenk's result and that which follows from these extinction-curves is explained. The two different liquid-crystalline states are also found to be affected to a different degree under the influence of a magnetic field. H. H. Ho.

313. *Transition Temperatures of Strontium Chloride and Strontium Bromide as Fixed Points in Thermometry.* **T. W. Richards and V. Yngve.** (Am. Chem. Soc., J. 40. pp. 89–95, Jan., 1918.)—After describing two methods for the preparation of pure strontium chloride, and confirming the existence of strontium chloride dihydrate, the authors give details of their measurements of the transition temperature of strontium chloride hexahydrate; this temperature is found to be 61·341° on the international hydrogen scale. Evidence is also given for the existence of a strontium bromide dihydrate, and the transition temperature of strontium bromide hexahydrate into the dihydrate is found to be approximately 88·62° on the international hydrogen scale. T. S. P.

314. *Some neglected Points with regard to the Thermal Treatment of Steel.* **M. E. Leeds.** (Am. Soc. Testing Materials, June, 1915. Rev. de Mét. 14E. pp. 210–214, Sept.–Oct., 1917.)—The functions of the furnace in the industrial heat-treatment of steels are frequently lost sight of, and it is of importance to know the temperature of the article, not only at the surface but also in its interior, at each moment of the heating. Experiments carried out on the rate of heating of various-sized pieces of steel placed in furnaces at various temperatures showed that while small specimens heated up more rapidly than larger ones the results were of very little use in practice since the total effect depended upon the size and type of furnace and other conditions. The relations between the temperature of the furnace and the rate of heating were curious, for while the time of heating was shorter at 649° than at 538° C. it was considerably longer when the temperature of the furnace was at 760°, owing, of course, to the large absorption of heat by the steel during the critical range. Above 760° C. the time of heating decreased very rapidly with increase in the temperature of the furnace, owing to so large a proportion of the heat being transmitted by radiation from the walls of the furnace; this transmission being proportional to the fourth power of the difference in temperature between the specimen and the walls of the furnace. Even in specimens of large diam. there is little difference between the temperatures at the surface and in the interior. This difference is naturally greater as the rate of heating increases. In practice, the author recommends the use of two couples, one in the furnace and the other on the surface of the specimen. By the aid of a triple thermo-couple so fixed that while one couple is in contact with the surface of the specimen the others are embedded at various depths, the author has been able to follow the transformations occurring during both heating and cooling on the surface and in the interior of the steel. The determinations of the critical point of the steel can be determined in this way without any exact calibration of the couple since the determination solely depends on the time of the transformation. F. C. A. H. L.

315. *The Heterogeneity of Steels.* **G. Charpy** and **S. Bonnerot.** (Comptes Rendus, 165. pp. 536–540, Oct. 22, 1917.)—The authors have carried out numerous tests with the cupriferous reagent of le Chatelier and Lemoine [Abs. 119 (1916)], the use of which has been modified by subsequent solution of the deposited copper in ammonia. In annealed mild steels copper is deposited almost simultaneously on the pearlite and ferrite, but after treatment with ammonia the ferrite appears black and the pearlite white. By means of this reagent the authors have studied the effect of various amounts of rolling on the original dendritic structure of a steel ingot. Heat-treatment processes, although modifying the distribution of the carbon, have little or no effect on the patterns produced by the cupriferous reagent whether in the ingot or rolled bar. This is true even of prolonged and energetic heat-treatments, so that the size of the striæ in a rolled bar is always an indication of the amount of work which has been done on it, assuming that the dimensions of the primitive dendrites are known. The study of these dimensions and their variations with the conditions of casting is of great interest, and use of the reagent shows that the size of the ingot has very little effect on the small dendrites formed at the beginning of solidification by contact with the walls of the mould. On the other hand the dimensions of the primary crystals formed in the interior increase greatly with the mass of metal. The quantity of metal solidifying at one time has a much more pronounced effect than the rate of cooling, which points to the important rôle played by liquation, which, when marked, may give rise to variations of the order of 1 to 10 between the dimensions of the peripheral and central dendrites. Heterogeneity in steels requires to be studied from two points of view : (1) a consideration of the relative dimensions of the striæ in juxtaposition, which vary considerably in different parts of the mass and are largely determined by the composition of the steel, the shape and size of the ingot, and the amount of work to which it has been subjected ; (2) a definition of the degree of heterogeneity or the differences in composition of the various bands. While the cupriferous reagent renders the first part of the study possible it cannot give any precise evidence on the second point. F. C. A. H. L.

316. *Thermal Dilatation and Rate of Solution of Carbon Steels.* **J. Driessen.** (Rev. de Mét. 14. pp. 683–706, Sept.–Oct., 1917.)—A study has been made of the thermal dilatation of iron-carbon alloys containing 0·05 to 3·9 % carbon and impurities which in no case exceeded 0·3 %, over the temperature-ranges 20°–200°, 200°–500° and 500°–1000° C. The variation in length-temperature curves showed discontinuities at about 180° corresponding with the cementite transformation. α cementite, stable below 180°, has a lower coefficient of dilatation than ferrite, while the value for β cementite, stable above 180°, is sensibly the same as that of ferrite. At higher temperatures discontinuities appear corresponding to the thermal critical points, the pearlite transformation taking place at 739° on heating and 707° on cooling. These figures are some 10 to 20 deg. higher than the values obtained by le Chatelier and Charpy and Grenet, but the $\gamma - \beta$ and $\gamma - \alpha$ changes occur at the same temperatures as those obtained by these investigators. Excessively slow cooling gave a somewhat higher value for the pearlite change-point. Contrary to the results of le Chatelier, but in agreement with those of Charpy and Grenet, the dilatations above the A1 point of alloys containing up to 0·85 % carbon are practically constant. Above 0·85 % carbon the alloys show a marked max. coefficient of dilatation above

900° in an alloy containing 1·7 % carbon. During the critical range an alloy containing 0·85 % carbon, shows the max. variation in length. Alloys containing over 0·65 % carbon quenched from above 900° contract on reheating to 300°. With over 1 % carbon a similar contraction occurs at 100°–150. In some cases, contractions occur between 275°–340° on lower carbon steels quenched from 940° or 750° C. Quenched steel maintained between 20° and 500° for some time undergoes a permanent contraction, the max. effect occurring at 0·9 % carbon. The results of the solubility of quenched and tempered steel in dilute acid solutions confirm those of Heyn and Bauer. In addition to the max. solubility at 350°–420° there is a slight minimum at 170° C. Curves representing the rates of solution of quenched and tempered steel as functions of the carbon content are not rectilinear; there is an abrupt change of direction at 0·9 % carbon. F. C. A. H. L.

317. *The Heterogeneity of Steels.* **H. le Chatelier** and **E. L. Dupuy.** (Comptes Rendus, 165. pp. 849–852, Sept. 10, 1917.)—Further improvements have been effected in the etching agent previously described [in Abs. 119 (1916)] by altering its composition to ethyl alcohol (95), 100 cm.^{3}; water, 10 cm.^{3}; cryst. copper chloride 1 gm.; picric acid 0·5 gm.: conc. HCl 1·5–2·5 cm.^{3}. The proportion of alcohol is important, but of most importance is the exact content of HCl, which has to be determined by trial for each particular case. Two solutions are made up, one containing 1 cm.^{3} HCl and the other 3 cm.^{3}, and these are mixed in varying proportions determined by experiment. The 1 cm.^{3} solution of HCl does not give a copper deposit, while the 3 cm.^{3} solution deposits copper uniformly over the surface of the specimen. A specimen is placed in the weaker solution, and the stronger solution added until max. contract is obtained. When the specimen is made the anode in a saturated solution of sodium bicarbonate and a current of 0·1 amp./cm.^{2} passed through the circuit, the thick deposit of copper becomes black, but thin deposits are cleared, and thus the contractions are increased. By such treatment heterogeneity can be revealed in steels containing as little as 0·015 % P. F. C. A. H. L.

318. *Osmotic Pressure.* (Faraday Soc., Trans. 13. pp. 119–189, Dec., 1917. Discussion.)—This discussion on osmotic pressure consists of an Introductory Address by **O. J. Lodge**, followed by a number of papers, namely, "The kinetic theory of osmotic pressure," by **A. W. Porter**; "The colloidal membrane," by **F. Tinker**; "Osmotic pressure in relation to the constitution of water," by **W. R. Bousfield**. To conclude with there is a general discussion on the papers. L. H. W.

319. *Precipitation of Colloidal Gold and Platinum on Metallic Surfaces.* **E. B. Spear** and **K. D. Kahn.** (Am. Chem. Soc., J. 40. pp. 181–184, Jan., 1918.)—It is shown that metallic plates precipitate colloidal Pt and Au in the same order as the metals occur in the electrode potential series, the most active metal requiring the least time. The metals used were Zn, steel, Ni, Pb, Sn, Cu, and Pt. A roughened surface or a finely divided metal requires less time than the same metal if the surface is smooth. The metal dissolves in the colloidal solution, is adsorbed, and then carried down by the colloid, and its precipitating effect may be explained on the same basis as that of electrolytes. T. S. P.

320. *Mechanism of the Ionisation Process.* **J. Kendall** and **J. E. Booge.** (Am. Chem. Soc., J. 39. pp. 2323–2338, Nov., 1917.)—In previous articles

V.2
191

[compare Abs. 2086 (1914)] it has been shown that there is an intimate and general connection between ionisation and compound-formation in solutions. The hypothesis is now advanced that "ionisation is preceded by combination between solvent and solute, and is, indeed, a consequence of such combinations." This viewpoint combines the current ionic and hydrate theories, referring conductivity in solutions to the dissociation of solvent-solute complexes into radicals of opposite charge. The actual mechanism of the ionisation process under this assumption, with its relation to phenomena such as unsaturation, association and high dielectric constant, is briefly discussed. It is shown that compound-formation between solvent and solute may be postulated in all conducting solutions, and that the distinction still commonly retained between the two components is arbitrary and misleading. The general evidence in favour of the theory put forward is presented in a preliminary form only, attention being centred on a few fundamental points. The work of other investigators is to be considered in a later paper, which will also contain a quantitative treatment of the subject. T. S. P.

321. *A Study of Hydrogen and Calomel Electrodes.* **G. N. Lewis, T. B. Brighton,** and **R. L. Sebastian.** (Am. Chem. Soc., J. 39. pp. 2245–2261, Nov., 1917.)—The authors collect in this paper the main results of investigations which have been in progress for many years and which have dealt with the potential of the hydrogen electrode in different concentrations of hydrochloric acid and of potassium hydroxide; with the dissociation constant of water; with the potential of calomel and silver chloride electrodes in solutions of potassium chloride and of hydrochloric acid; with the problem of establishing definite and reproducible potentials at the boundaries between solutions; and with improvements in the experimental procedure used in such investigations. To prevent electric leaks, the thermostat bath was filled not with water but with a high-boiling petroleum oil—so-called petrolatum oil—and the apparatus was all carefully protected by metallic shields to prevent external leaks. At least two cadmium cells of 1·0181 volts were always kept in the thermostat and were checked against each other and against fresh cells which were made up from time to time. As a working battery a large cell of the Hulett type containing unsaturated $CdSO_4$ solution proved extremely satisfactory. Great care was taken with the purification of materials. The hydrogen used was produced electrolytically in a special cell from caustic soda solution. As electrodes for the hydrogen cells, gold coated electrolytically with finely divided iridium was employed. All calomel and silver electrodes were referred to the normal calomel electrode. One of the most serious obstacles in the interpretation of exact measurements of e.m.f. is due to uncertainty regarding liquid potentials. It was desirable, therefore, to obtain reproducible values, and this the authors achieved by the use of a "dipping" contact. All measurements were carried out at 25°.

The following results were obtained: Difference between the tenth-normal and normal calomel electrode, $E = 0{\cdot}0529$ volt; liquid potential between tenth-molar KCl and HCl, $E = 0{\cdot}0278$; for the hydrogen electrode in molar concentrion of hydrion, against the normal calomel electrode, $E = 0{\cdot}2828$. That is, if the potential of the normal hydrogen electrode is taken as zero, the potential of the normal calomel electrode is $-0{\cdot}2828$. The hydrogen electrode in 0·1 M-KOH solution combined with the normal calomel electrode gives $E = 1{\cdot}0802$. For the potential of hydrogen in (hypothetical) molar OH' solution against the normal calomel electrode, $E = 1{\cdot}1106$, and for the combination of hydrogen electrode in molar OH' solution against hydrogen in molar H′ solution, $E = 0{\cdot}8278$. From this the dissociation constant of water is calculated, $K_w = 1{\cdot}012 \times 10^{-14}$ or the concentration of hydrion or hydroxidion in water at $25° = 1{\cdot}006 \times 10^{-7}$. A. F.

322. *Electrolysis of Solutions of the Rare Earths.* III. **L. M. Dennis** and **A. B. Ray.** (Am. Chem. Soc., J. 40. pp. 174–181, Jan., 1918.)—In a previous paper [Abs. 1787 (1915)] it has been shown that fractional precipitation and separation of the rare earths can be brought about by the electrolysis of aqueous solutions of their salts at voltages considerably higher than the decomposition values of these compounds. From the theory given previously it would follow that the fractionation should proceed more evenly, and the separation be more complete, as the vigour with which the electrolyte is stirred is increased. This deduction is now shown to be in accordance with experimental facts. T. S. P.

323. *Lead Standard Cell and a Determination of the Potential of the Lead Electrode.* **W. E. Henderson** and **G. Stegeman.** (Am. Chem. Soc., J. 40. pp. 84–89, Jan., 1918.)—The following standard cell, Pb amalgam | $PbSO_4$ | $Na_2SO_4{,}10H_2O$ | Hg_2SO_4 | Hg, is found to possess a constant voltage which is reproducible to within a few hundredths of a millivolt. The e.m.f. at any desired temperature is given by the equation: $E_t = 0{\cdot}96463 + 0{\cdot}000174(t - 25°) + 0{\cdot}00000038(t - 25)^2$. Over an extended range of time the voltage shows a gradual decrease—a property frequently found in other cells.

A determination of the potential of the lead electrode against the tenth-normal calomel electrode, using the combination Pb | $PbCl_2$ sat. | 0·1N-KCl | Hg_2Cl_2 | Hg gave the value 0·4696 at 25°. T. S. P.

324. *Theory of the Lead Accumulator.* **C. Féry.** (J. de Physique, 5. pp. 187–191, May–June, 1916.)—The author describes further experiments upon the action of the lead accumulator. By using a very small positive, containing a known amount of active material, discharged between two large negatives, the author obtains a figure for the active material required per ampere-hour on discharge. By considering the theoretical amount that would be required of various oxides the conclusion is reached that the active material must have a higher degree of oxidation than that of Pb_2O_5. From a similar experiment on a small negative plate the author concludes that hydride of lead plays no part, and that the action is simply due to lead sulphate. The view is expressed that normal sulphating takes place from the outside inwards and that reduction takes place from the support outwards. W. R. C.

V.2
191